A HISTORY OF INFUSORIA,

INCLUDING

THE DESMIDIACEÆ AND DIATOMACEÆ,

BRITISH AND FOREIGN.

BY

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AUTHOR OF THE 'MICROSCOPIC CABINET,' ETC.

FOURTH EDITION.

ENLARGED AND REVISED BY

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ILLUSTRATED BY FORTY PLATES.

LONDON:
WHITTAKER AND CO., AVE MARIA LANE.
1861.

PRINTED BY TAYLOR AND FRANCIS,
RED LION COURT, FLEET STREET.

ALERE FLAMMAM.

PREFACE.

SPECIAL interest has always been taken by man in the structure and development of the minute forms of life, whether animal or vegetable: in this volume I propose to lay before the reader a *résumé* of the present state of our knowledge of the multitude of living beings called Infusoria. This term, as employed by Professor EHRENBERG of Berlin, includes a wide range both of animal and vegetable life; while it is now restricted by other naturalists to the Protozoa, and, in the works recently commenced by Dr. STEIN and MM. CLAPARÈDE and LACHMANN, to the ciliated members of that group.

The former editions of this work having included a History of the Bacillaria, Phytozoa, Protozoa (under the name Polygastrica), and of the Rotatoria, it is incumbent on me to retain these groups, though the researches of late years have so extended our acquaintance with them that much difficulty has been felt in the attempt to comprise the whole in a single volume, so necessary for a practical manual.

The successful investigation of this department of Natural History arose mainly from the improvement of the microscope consequent upon the discoveries of "Test Objects" and "penetrating power," the latter depending upon "angular aperture,"—discoveries which my colleague the late Dr. GORING and myself had the pleasure of presenting to the public. The microscope, having become thereby a reliable instrument, has revealed to us the true forms and structure of these beings.

Part I. is devoted to a General History of the several more or less natural groups of Infusoria: it contains also the observations and opinions of British and Continental naturalists on their nature, structure, functions, and classification. The foreign writings on these subjects are so voluminous that even an abstract of them has increased this part of the work much beyond what it occupied in former editions, while the introduction of the Tables from Part II. has further extended it; but, as I have been anxious to give an impartial account of the researches on this subject, a briefer summary might have impaired its usefulness and value. To Dr. ARLIDGE is due the rearrangement and preparation of this part.

Part II. contains descriptions of the Families, Genera, and Species of the groups whose general history forms the subject of the preceding part of this volume. The systematic arrangement of Ehrenberg has been retained for the Phytozoa, Protozoa, and Rotatoria, the new genera and species of other naturalists being collated and engrafted thereon. The descriptions of those curious and highly-organized creatures the Rotatoria have been extended and revised by Professor WILLIAMSON of Manchester, whose original researches and observations on this group are greatly appreciated, both in this country and abroad.

In consequence of the long illness of Mr. RALFS, who had undertaken the revision of the Bacillaria, the publication of this edition has been delayed, and that group has been printed last—a deviation from the original design which it is hoped will not inconvenience the reader, while it has allowed opportunity for the insertion of the latest researches. Owing to the circumstance stated above, the revision of the Systematic History of the Family or Subgroup Desmidiaceæ has been kindly carried out by Mr. WILLIAM ARCHER of Dublin, who has added some original views, expressing by symbols the characters of certain genera; moreover, M. DE BRÉBISSON of Falaise has given this edition the benefit of his valuable co-operation, by furnishing descriptions of the newly-discovered foreign species.

The elegance and variety of the forms, the beauty and elaborate sculpturing of the silicious shells of the Diatomaceæ, and the general interest now taken in their study, rendered it desirable to bring together in this volume all the known genera and species, British and foreign. This I have been able to effect by the research of Mr. RALFS, whose name is so intimately identified with the knowledge of these organisms, and whose present arrangement of their families and genera will no doubt tend to facilitate our better acquaintance with them. Owing to the great dimensions which this treatise has acquired, and the limited space consequently at command, I was under the necessity of condensing the manuscript of Mr. RALFS, and of introducing abbreviations. Still I have, in accordance with my original design, given every known specific name, whether synonym or variety, whereby observers may avoid confusion in the nomenclature by not employing the same names for newly-discovered forms. The references now introduced are to works published subsequently to the early editions of this book: for their verification I am indebted to Mr. KITTON of Norwich.

Twenty-one new Plates have been added to this edition, of which six are engraved by Mr. TUFFEN WEST. In the case of the Diatoms, all the new figures are drawn to one scale, representing a magnifying power of 300 diameters; many of them likewise are drawn from specimens, whilst others are engraved from original drawings kindly lent by Mr. GEORGE NORMAN of Hull, Mr. ROPER of Clapton, and Mr. BRIGHTWELL of Norwich.

It now becomes my pleasing duty to acknowledge the kind assistance received from the late Professors GREGORY of Edinburgh and BAILEY of New York; also to tender to Drs. DONKIN, GREVILLE, FRANCIS, WALLICH, STRETHILL WRIGHT, and Mr. GOSSE, along with the gentlemen before named, my best thanks for their aid and advice during the progress of this laborious undertaking.

In conclusion, should the object proposed in the reissue of this work be attained, viz. to produce in a single volume a compendium of the present state of knowledge, calculated to promote and facilitate the study of the very interesting branch of Natural History which forms its subject, and which has occupied much of my leisure time for more than forty years, I shall be fully content.

ANDREW PRITCHARD.

Canonbury, London, N.
November 15, 1860.

CONTENTS.

PART. II.—A SYSTEMATIC HISTORY OF INFUSORIA, WITH DESCRIPTIONS OF THE FAMILIES, GENERA, AND SPECIES.

A

LIST OF ABBREVIATIONS

OF

WORKS AND AUTHORS' NAMES REFERRED TO IN THE PRESENT EDITION.

Abhandlungen der Berliner Academie der Wissenschaften.
Abhandlungen der Senckenbergischen Gesellschaft in Frankfurt am Main.
Ag CD. or AD. Agardh's Conspectus Diatomorum.
ANH. Annals and Magazine of Natural History.
Anat. d. wirbellos. Thiere. Siebold, C. Th. von. Lehrbuch der vergleichenden Anatomie der wirbellosen Thiere. Berlin, 1848.
Ar. or Arn. Professor G. Walker-Arnott, LL.D.
ASA. or AA. Agardh's Systema Algarum.
ASN. or Ann. d. SN. Annales des Sciences Naturelles, Paris.
B. or Bai. Professor Bailey of New York.
BAJ. Professor Bailey, in American Journal of Science.
BC. or BSC. Professor Bailey's Contributions to Knowledge, Smithsonian Institution.
BMO. Professor Bailey's Microscopic Organisms
Boston Journal of Natural History. 1853.
Braun, A., Prof. Algarum Unicellularum Genera nova aut minus cognita. 1855.
Bréb. M. de Brébisson of Falaise.
BD. M. de Brébisson's Diatomaceæ of Cherbourg.
Bri. T. Brightwell, Esq., Norwich.
Brit. Assoc. Transactions of the British Association for the Advancement of Science.
British Desmidieæ. By John Ralfs. 1848.
Brit. and Foreign Med. Rev. British and Foreign Medico-Chirurgical Review.
Bulletin de L'Académie de St. Pétersbourg, xiii. 1855.
Carpenter, Dr. W. B. The Microscope.
Carus. Icones Zootomicæ. 1858.
Cohn, R. S. Professor Cohn on the Structure of *Protococcus pluvialis*. Ray Society, 1853. London.
Comptes Rendus de l'Académie Impériale des Sciences.
D'Orbigny, Alcide, Foraminifères Fossiles, 1846.
Duj. or Du. Dujardin, F., Histoire Naturelle des Zoophytes.—Infusoires. Paris, 1841.
E., Eh., or Ehr. Professor Ehrenberg, Berlin.
EA. Professor Ehrenberg's Mikroscopischen Lebens in Amerika.
Edin. New Phil. Journ. Edinburgh New Philosophical Journal.
Einzell. Alg. Nägeli, Prof., Gattungen einzelliger Algen. Zurich, 1849.
EI. or Inf. Professor Ehrenberg's Die Infusionsthierchen.
EK. Professor Ehrenberg's Kreidethierchen.
EM. Professor Ehrenberg's Mikrogeologie.
ERBA. or EB. or ER. Professor Ehrenberg in Reports of Berlin Academy.
Ehrenberg, Prof. Passatstaub und Blutregen.

Entw. Cohn, Prof. F. Entwickelungs-geschichte der mikroskopischen Algen und Pilze. 1854.
Fauna Infusoria, Norfolk. T. Brightwell, Norwich.
Gr. Dr. R. K. Greville.
GBF. Dr. R. K. Greville's British Flora.
GCF. Dr. R. K. Greville's British Cryptogamic Flora.
Greg. Dr. Gregory of Edinburgh.
GDC or GC. Dr. Gregory's Diatomaceæ of the Clyde.
HBA. Hassall's British Algæ.
Jones, T. Rymer, Prof. A General Outline of the Animal Kingdom. London, 1841.
K. or Kütz. Professor Kützing.
KA. or KSA. Professor Kützing's Species Algarum.
KB. Professor Kützing's Bacillarien.
Kützing. Phycologia Germanica. 1845.
KL. Die kleinsten Lebensformen.
KSD. Professor Kützing's Synopsis Diatomeorum.
Linnæa, xiv. 1840.
Lyngb. Professor Lyngbye's Tentamen Hydrophytologiæ Danicæ.
Medical Times. London, 1856. Professor Huxley's Lectures.
Me. or Men. Professor Meneghini.
Meneghini, R. S. Professor Meneghini on the Animal Nature of Diatomeæ. Ray Society. London, 1853.
Mém. de l'Acad. Roy. Belgique. Mémoires de l'Académie Royale de Belgique.
Micrographic Dictionary, The. By Dr. Griffith and Prof. Henfrey.
Microscopic Illustrations. By C. R. Goring, M.D., and Andrew Pritchard.
Mittheilungen der Naturforschenden Gesellschaften in Bern. 1849.
MJ. or JMS. Journal of Microscopical Science.
Monatsb. Berlin. Acad. Monatsbericht der Berliner Academie.
MT. or TM. or TMS. Transactions of Microscopical Society.
Müller's Archiv. Archiv für Anatomie und Physiologie. Von Dr. J. Müller.
Müller, O. F. Prof. Animalcula Infusoria.
Nä. or Näg. Professor Nägeli.
Nat. Hist. Review. Natural History Review, Dublin.
Nov. Act. Acad. Curios. Nova Acta Academiæ Naturæ Curiosorum.
Owen, Richard. Lectures on the Invertebrate Animals. London, 1843.
Owen, Richard. On Parthenogenesis. London, 1849.
Ph. Professor John Phillips, F.R.S.
Phil. Trans. Philosophical Transactions of the Royal Society of London.
Perty, Max., Dr. Zur Kenntniss kleinster Lebensformen. 1852.
Proceedings of the American Association for the Advancement of Science.
Proceedings of the Boston Society of Natural History.
Proc. Roy. Soc. Proceedings of the Royal Society of London.
Proc. Roy. Soc. Edin. Proceedings of the Royal Society of Edinburgh.
Proceedings of the Academy of Natural Sciences of Philadelphia. 1853.
Rab D. or RD. Dr. Rabenhorst, Die Süsswasser Diatomaceen.
Ra. or R. Mr. Ralfs.
R.S. Ray Society's publications.
R.S. Reports. Ray Society Reports.
Rejuv. R.S. Braun, A., Professor, On the Phenomena of Rejuvenescence in Nature. Ray Society. London, 1853.
Ro. F. C. S. Roper, Esq.
Schleiden, J. M., Prof. Principles of Scientific Botany: translated by Dr. Lankester. 1859.
Schultze, Dr. Max S. Ueber den Organismus der Polythalamien. Leipzig, 1854.
Schneider, Ant. Symbolæ ad Infusoriorum Historiam Naturalem Dissertatio Inauguralis. Berlin, 1854.
Sh. or Shadb. G. Shadbolt, Esq.
Sill. Journ. Silliman's American Journal of Science and Arts.
S. or Sm. Professor Smith.
SBD. or SD. Professor Smith's Synopsis of British Diatomaceæ.
Stein, F., Prof. Die Infusionsthiere, auf ihre Entwickelungsgeschichte.

Transactions of the Philosophical Society of Manchester.
Transactions of the Medical and Physical Society of Bombay.
Untersuchungen über die Familien der Conjugaten. By Professor de Bory.
Van der Hoeven. Lehrbuch der Zootomie. 1850 & 1856.
Wagner. Zootomie.
Wiegmann's Archiv. Archiv für Naturgeschichte. Von A. F. A. Wiegmann.
Williamson, Prof. On the Recent Foraminifera of Great Britain. Ray Society. London, 1857.
Zeitschr., or Siebold's Zeitschr. Zeitschrift für wissenschaftliche Zoologie. Von Carl T. von Siebold und Albert Kölliker. 1848–59.

NOTE.—The names of Ehrenberg, Dujardin, Perty, and Siebold are frequently mentioned without particular notice of the work quoted; but the treatises intended are those in which each of those several authors has given a general history of Infusoria, and which are named in the above list. So, in the account of the Rhizopoda, Schultze is often quoted, his special work on their organization being referred to; and lastly, in the History of the Rotatoria, the opinions of Leydig are all derived from his essays in Siebold's 'Zeitschrift.'

For abbreviations employed in Systematic History of Desmidiaceæ, see p. 721.

NOTE.—The references to the engravings in this work are printed thus: (XII. 20.) for Plate XII. fig. 20.

ERRATA, ETC.

Page 10, line 8 from bottom, *dele* See Appendix at end.
— 218, line 7 from top, *for* Foraminiffera *read* Foraminifera.
— 243, line 7 from bottom, *for* peuliarity *read* peculiarity.
— 258, line 3 from top, *for* Actinophrgs *read* Actinophrys.
— 259, line 4 from bottom, *for* XVIII. *read* XXIII.
— 316, line 6 from bottom, *for* Leuckhart *read* Leuckart.
— 324, line 14 from bottom, *for* Wagener *read* Wagner.
— 470, line 7 from top, *for* 1855 *read* 1858.
— 535, line 5 from bottom, *after* figured, *insert* subsequently.
— 726, col. 2, line 20 from bottom, *insert* segment 3-lobed, *before* lateral lobes.
— 726, col. 2, line 11 from bottom, *for* side *read* sides.
— 729, col. 2, line 25 from bottom, *dele comma after* surface, *and insert after* middle.
— 732, col. 2, line 22 from bottom, *for* finely *read* finally.
— 735, insert "C. *aciculare* (West).—Elongated, very slender, straight, except at extremities."
— 741, col. 2, *transpose* reference to figure from *S. globulatum* to *S. bacillare*.
— 744, col. 2, line 34, for *paradoxum* read *tetracerum*.
— 753, line 18 from top, *for* Pediastrium *read* Pediastrum.
— 758, line 5 from bottom, *dele* Synedreæ. (*See* p. 940.)
— 760, col. 1, line 28, *after* capitate, *insert* striæ.
— 761, col. 1, line 4 from bottom, *for* 159 *read* 156, and *insert* XI. 1–8.
— 764, *for* E. Terra *read* E. Serra.
— 765, col. 2, line 2 from bottom, *for* Argus *read* Arcus.
— 768, *after* Genus Oncosphenia, *insert* Genus Podosphenia from p. 769.
— 771, col. 1, line 14, *for* broadly *read* loosely.
— 772, col. 2, line 5 from bottom, *for* pear-like *read* pearl-like.
— 773, col. 1, line 10 from bottom, *for* III. *read* XIII.
— 774, col. 1, line 5, *insert* (IV. 32.)
— 775, *transpose* Odontidium mesodon *to end* O. hyemale *as syn.*
— 775, for "O. *pinnatum*" read *pinnulatum*.

Page 777, end of F. *virescens*, insert (IX. 176.)
— 778, line 6, *after* Ralfs, *insert* .—
— 779, *before* Genus Nitzschia, *insert* Fam. characters of Surirelleæ from p. 783: and see *Note*, p. 940.
— 781, col. 1, line 2 from bottom, *for* 20 *read* 21.
— 783, col. 1, line 12, *for* 22 *read* 23.
— 784, col. 1, line 5 from bottom, for 2, 3; *read* 24.
— 784, col. 2, line 22 from bottom, *for* 19 *read* 20.
— 786, S. pulchella, *insert* (IV. 28.)
— 789, S. fulgens, *insert* (XIII. 20.)
— 791, col. 1, line 2, *for* XVIII. *read* VIII.
— 796, S. striatula, *insert* (IX. 137, 138.)
— 798, col. 1. line 24, *for* dividuate *read* dimidiate.
— 799, col. 1, line 21 from bottom, *for* magnificent *read* marginal.
— 802, col. 2, line 14, *for* XV. *read* XII.; line 29, *for* XV. *read* XII.; last figure, *for* 56 *read* 50.
— 806, Gomphogramma rupestre, *insert* (IV. 46.)
— 806, Tetracyclus lacustris, *insert* (VIII. 10.)
— 809, Gephyria incurvata, *insert* (V. 50.)
— 809, Gephyria media, *insert* (V. 49.)
— 809, Eupleuria pulchella, *insert* (VIII. 2.)
— 812, *for* C. undulata *read* C. undata.
— 821, col. 2, line 6, after *ochracea*, insert (Ralfs) from next line; and after *ferruginea* insert (Ehr.).
— 836, col. 2, line 8 from bottom, *for* X. *read* XI.
— 844, A. Kittoni, *insert* (VIII. 24.)
— 851, col. 1, line 17 from bottom, for *nervosa* read *enervis*.
— 863, Dicladia Capreolus, *insert* (VI. 28.)
— 875, Cymbella Arcus, *insert* (VII. 78.)
— 891, col. 1, line 2 from bottom, *for* XII. *read* XI.
— 893, for "N. *dissimilis* (Rab.)" read "N. *clepsydra* (Ralfs)."
— 903, for "N. *producta*" read "N. *extensa*."
— 911, S. *Fulmen* (Breb.), read "S. *Fulmen* (Bri.)," and insert that species after S. *constricta*.
— 923, col. 1, last line, *for* (VIII. 43.) *read* (VIII. 48.)
— 929, col. 1, top line, for *octocarpoides* read *ectocarpoides*.
— 938, col. 1, line 9, for "C. *radiata*" read "C. *stylorum*."
— 941, Actinoptychus Jupiter, *now* Actinocyclus Ehrenbergii.
— 952, in description of PLATE VII., *insert* "**78.** Cymbella Arcus, to right of fig. 42. **79.** Amphora monilifera, to right of fig. 49." [*Note*. The engraver has omitted the numbers to these two figures in that Plate.]

WORKS BY THE SAME AUTHOR.

MICROSCOPIC ILLUSTRATIONS, with Descriptions of the New Microscopes, Rules for constructing them, and Directions for their management.

MICROSCOPIC CABINET, with Descriptions of the Jewel and Doublet Microscopes, Test Objects, &c.

MICROGRAPHIA, with practical Essays on Eye-pieces, Solar and Gas Microscopes, &c.

NOTES ON NATURAL HISTORY, selected from the 'Microscopic Cabinet,' with 10 coloured Plates from original Drawings by C. R. GORING, M.D.

MICROSCOPIC OBJECTS: Animal, Vegetable, and Mineral.

A LIST OF ENGLISH PATENTS for the first Forty-five Years of the present Century.

PART I.

A GENERAL HISTORY OF INFUSORIA.

SECT. I.—OF THE BACILLARIA.

UNDER this designation, contrived by Ehrenberg, two families of microscopic unicellular Algæ are comprehended, viz. the DESMIDIEÆ and the DIATOMEÆ.

The Diatomeæ differ from the Desmidieæ chiefly by their dense silicious envelope, composed of two opposite portions or valves and of an interposed segment, and by the general absence of the usual green colouring matter of plants—chlorophyll or chromule. The Desmidieæ, on the contrary, have a non-silicious envelope, separable into two segments, and filled with bright grass-green chromule. In various vital phenomena the two tribes accord; but whilst the Desmidieæ are all but universally admitted to be plants, the Diatomeæ are still regarded by many to be of an animal nature. With respect to this question, the arguments *pro* and *con.* will be best understood when the organization and vital endowments of these beings have been discussed.

I.—OF THE FAMILY DESMIDIEÆ OR DESMIDIACEÆ.

(Plates I. II. III. and XVI.)

The Desmidieæ are (pseudo-)unicellular Algæ of a herbaceous green colour, of freshwater habit, and have a membranous lorica composed of two symmetrical segments or valves. In Kützing's arrangement (*Sp. Alg.*), the Desmidieæ constitute a family of the Chamæphyceæ, a suborder of the class Isocarpeæ. Ehrenberg treated the genus *Closterium* as a distinct family, which he placed between the Vibrionia and Astasiæa, with the name Closterina.

That the Desmidieæ are actually unicellular (in the sense of forming a single enclosed cavity), Mr. Ralfs has, in his most valuable monograph on the family (1848), taken much pains to demonstrate. Owing to the very deep constriction of the fronds of many genera, *e.g.* of *Euastrum* and *Micrasterias*, the appearance of the little organism is that of two cells united by a narrow band (I. 1, 2, 24, 26, 27; II. 18, 28), forming, in Ehrenberg's opinion, a binary cell or frustule. However, between such deeply partite forms, and others in which no constriction is perceptible, for instance in *Closterium*, every intermediate gradation is met with. Other evidence of the unicellular structure is afforded by the phenomena of conjugation and of the formation of sporangia, by the newly-formed segments resulting from self-fission being interposed between the old valves, and by the fact that the entire contents will escape through an opening made in either valve. Moreover, in several genera the circulation of portions of the contents throughout the frond, from one segment to the other, clearly demonstrates the continuity of their interior.

FIGURE.—There is great variety in the figure of Desmidieæ, and much beauty. This will be best illustrated by reference to the Plates I. and II.; for description alone would fail to convey even a tolerably accurate conception. In *Micrasterias* (I. 18, 20, 21) the frustule has a general circular outline, but is bipartite and variously cut. In *Euastrum* (I. 23, 24, 26; II. 10) it is bipartite, and each valve deeply sinuated. In many species of *Cosmarium* (I. 1, 2; II. 33) the constriction is much shallower, the valves hemispherical, and their margin entire. In *Staurastrum* (I. 31–34; II. 3, 7) each segment is more or less irregularly produced at the extremities into horn-like processes. In *Penium, Docidium,* and *Closterium* (II. 1, 2, 9, 14) the frond is elongated and wand-like, without constriction, or with only a very faint one, and in many species is, moreover, curved or crescentic. Not a few genera present numerous fronds united together; the outline of the compound being will consequently vary, both according to the figure of each individual frond, and especially to the mode in which the several fronds are united. Thus in *Hyalotheca, Desmidium,* and other genera (II. 35, 37, 39), the quadrate fronds are united side by side in single series, so as to form a chain or filament, in other words are concatenated.

The lateral view or cross-section of the fronds furnishes valuable characters, and is largely made use of by Mr. Ralfs with that object, especially to distinguish between the several filamentary species. His figures show that the fronds may be more or less compressed, and consequently offer on a transverse section (end view) an oval and more or less acuminate form (I. 25; II. 23, 29), further modified by the elevations and depressions which the surfaces possess (I. 25; II. 23). In other cases the section is circular, *e. g.* in *Hyalotheca* and *Didymoprium* (II. 32, 38), whilst in others, again, three or four sides exist which are commonly concave, as in *Desmidium* (II. 40).

The end view exhibits the arrangement of the mass of chlorophyll, which in some instances would appear to be peculiar and determinate of species.

The appearance of the Desmidicæ is much modified by the sinuosities, eminences, depressions, and processes, as well of the surface as of the margin of the fronds, and also by the depth and width of the central constriction. The surface may be dotted over irregularly, or more often regularly: the dots themselves are in most cases elevated points, and in fewer instances depressions. An irregular distribution of minute dots produces a granular-looking surface (I. 24; II. 23, 30). Where the spots are larger their elevated character becomes evident on the margin, to which they give a finely-toothed or dentate appearance, *e. g.* in *Cosmarium* (I. 1, 2, 3). In some elongated forms, such as *Tetmemorus* and *Penium* (II. 15), the puncta are disposed in lines parallel to the length: in *Docidium,* however, the disposition, so far as regular, is transverse. In several examples the surface is marked by elevated lines or by furrows (II. 6). Such markings seem peculiar to the elongated genera, particularly to *Closterium.*

Many apparent lines are resolvable by higher magnifying powers into rows of puncta. Where the lines are fine, they are said to produce a striation of the surface, as in *Closterium attenuatum* and *C. acerosum*; where they are more distinct they are termed costæ, and the surface they cover is costate or ribbed, as in *Closterium costatum* and *C. angustatum.* In general, in order to discover the striation of the surface, the fronds must be viewed when empty; sometimes indeed the lines can be made out at the extremities which are unoccupied by chlorophyll.

The striæ and costæ of *Closterium* and *Penium* referred to are disposed longitudinally, but frequently they are intersected at one or more points by a transverse line. In these spindle-shaped genera, where no constriction is found, one such transverse line, usually central, is constant, and indicates the point of separation into two valves (II. 1, 2, 9). Each valve again is occasionally subdivided by another line (II. 6, 15). These lines may be single or double, and in the case of the middle suture their number may be more multiplied, as in *Closterium lineatum* and *C. Ralfsii.*[*] The median sutural line is evident in other genera, *e. g.* in *Hyalotheca*, *Cosmarium*, and *Euastrum* (II. 35). In several it takes on a further development, and becomes an elevated ridge or band, appearing, in a front view, as a double line, terminating on each margin in a dentation. Instances occur in *Docidium* and in *Didymoprium* (II. 9, 39). Such double lines are also sometimes met with on each side the median suture, and at others, among the concatenate forms, at the junction-surfaces of connected fronds.

That the dots or puncta on the surface of the frustules are commonly small elevations has already been stated; a further development of such into papillæ or minute spines crowned by a globular apex is seen in *Micrasterias papillifera*; whilst in many *Cosmaria* and *Staurastra*, the edge or the entire surface is bedecked by fine hair-like spines or by obtuse ones, looking on the margin like crenations (I. 1, 2, 3). When short and stout, many elevated processes of the surface are called tubercles (II. 16, 17); when long and tapering, they constitute spines, and in this form may be either straight or curved: such are especially produced from the angles of the fronds, as in *Arthrodesmus* (II. 18, 28). Among the *Staurastra*, illustrations of forked spines (II. 3, 7) are found; whilst among sporangia of many species, spinous processes, besides tubercles and other appendages, are highly developed (II. 22, 25, 34) and attain their most complex conditions.

The modification of surface in several genera seems due, not to mere simple appendages, but to positive expansions of the limiting membrane itself into thick processes, which in their turn usually end in spines; instances occur in *Xanthidium* and *Staurastrum* (I. 27, 28; II. 3, 7, 20, 25). Generally these large productions from the surface occupy constant and definite positions, such as the extremities, the rounded angles of the fronds, or a margin, and are rarely indifferently placed. A general distribution over the surface is rather characteristic of *Xanthidium* (I. 27, 28). In *Euastrum* the surface is thrown into very broad round swellings, hence called inflations; such may be presumed to be constant in number and position (I. 24, II. 30, the empty divided fronds).

The margin of the more flattened, and the extremities of the elongated, species furnish important specific and generic characters. *Micrasterias* has its margin deeply incised into lobes (I. 18, 20, 21, 22), which, with reference to the centre of the frond, have a radiating arrangement, and are themselves incised or inciso-dentate. The fronds of *Euastrum* are more or less deeply sinuated (I. 23, 24, 26; II. 10), and the intermediate lobes produced vary both in dimensions and outline. Where the lobes on the margin of fronds are small and little prominent, they constitute crenations and dentations which may occur singly or in pairs; in the latter case, the margin so modified is said to be bidentate or bicrenate (I. 1, 2, 3; II. 31, 26, 37). For example, some fronds of *Euastrum binatum* are bicrenate on the sides, and those of *Didymoprium* at the angles of the filaments (II. 39), whilst bidentate frustules are seen in *Desmidium* (II. 37), and in *Hyalotheca mucosa*. It has been before remarked that when the surface is covered by tubercular eminences or conical granules, a dentate outline is produced; instances of this occur in *Euastrum verrucosum* and in several *Cosmaria*. Another variety of margin exists, known by the term undulated or wavy, where its elevations and depressions are comparatively shallow. Lastly, the general concavity or the convexity of the margin furnishes other specific characteristics.

Among the variations in the ends of the fusiform or elongated genera may be noticed the notched or emarginate apices of *Tetmemorus* (II. 12); the truncate extremities of *Docidium* (II. 9, 10), sometimes also, as in *D. Ehrenbergii*, tuberculate; and the more or less acutely conical apices of *Closterium*, prolonged in some species, as in *C. attenuatum*, by an abrupt contraction of the frond into a conical process—in others, as in *C. setaceum* and *C. rostratum*, by the gradual tapering of the whole frond—into long rostrate or setaceous beaks.

Colour.—This is due to the endochrome or internal substance, which is usually of a herbaceous green colour, and often diffused pretty uniformly throughout the fronds, sometimes however leaving intervals at which the enclosing membrane (lorica, *Ehr.*) becomes visible. This lorica is itself mostly colourless; yet in several species of *Closterium* and *Penium* it has a reddish-brown tint (II. 5, 6, 15). The green colouring matter of the interior is identical with that of plants, *i. e.* it is chlorophyll or chromule, and consequently undergoes a change of colour in autumn, becoming, like the leaves of plants at that season, a reddish-brown. When this change occurs, it is equally indicative of the termination of life.

Consistence.—Envelopes.—The limiting membrane of Desmidiaceæ is firm, though flexible; it exhibits some elasticity and considerable resistance to pressure, is not brittle, and not readily decomposable. Traces of silica are found in a few species, but not, says Mr. Ralfs, "in sufficient quantity to interfere with their flexibility." It is lined by a softer flexible membrane; and besides this, the Desmidieæ generally have an *external mucous or gelatinous covering*, mostly so transparent and homogeneous as to be overlooked. To bring it into view, it is a common plan to add some colouring matter to the water in which the organism is viewed; but good manipulation with a high power will frequently succeed without recourse to this expedient to demonstrate it. The particles of colour diffused about the frond, and indeed any external bodies, such as small vegetable cells, are seen, not in contact with the fronds, as they would often be if these were naked, but kept at a distance corresponding with the width of the hyaline envelope (I. 15; II. 35). In *Didymoprium Grevillii* and *Staurastrum tumidum* the mucous sheath is distinct and well defined; "in others (to quote Mr. Ralfs) it is more attenuated . . . ., and, in general, its quantity is merely sufficient to hold the fronds together in a kind of filmy cloud which is dispersed by the slightest touch. When they are left exposed by the evaporation of the water, this mucus becomes denser, and is apparently secreted in larger quantities to protect them from the effects of drought."

The lining or the primordial membrane of the firm lorica is thin, colourless, and highly elastic, and alters its contour with the varying movements of the endochrome which it immediately invests. It is in contact with the outer case only at some points, mostly about the centre, and being elsewhere free, an interval exists between the two envelopes. This elastic lining is acted on by various chemical reagents; for instance, it is contracted or corrugated by iodine and by acids.

Openings in Lorica.—Openings have been represented by several writers in the firm envelopes of Desmidieæ, and more particularly in those of *Closterium*. Ehrenberg, for instance, stated that apertures existed at the extremities, through which soft, very short, and conical transparent papillæ slightly protruded to serve as locomotive organs. Both Mr. Varley and Mr. Dalrymple also described terminal orifices, closed within, however, by a membranous envelope; but neither they nor any other observers have detected the papilla-like locomotive organs Ehrenberg represented. "In no instance

(Mr. Ralfs says) can any portion of the contents of the cell be forced out from the extremities." More recently the belief in terminal apertures has been revived by the published researches of the Rev. Mr. Osborne and others (*J. M. S.*), who affirm, that not only the outer hard case, but also the membranous lining is penetrated by foramina, through which water enters from without into the cavity of the frond. Another writer in the *Mic. Journ.*, Dr. Wright, describes, in a specimen of *Closterium didymoticum*, certain circular markings, consisting of two concentric rings, as apertures penetrating "both layers of the investing membrane at irregular intervals:" yet neither the character of these circular bodies, as represented by their observer, nor their irregular distribution, countenances such a notion, and the appeal he makes to Mr. Ralfs's figures, instead of aiding his argument, is totally subversive of it; for although, in the fronds of *Closterium didymoticum* and of *C. Ralfsii*, some large globules are distinguishable, these are in single linear series in a definite and constant position, except when disturbed from it by the death of the plant, or by its exhaustion by parasitic growths upon it, and clearly are not apertures. Besides, any such globules are sought in vain when the frond is empty, as Mr. Ralfs distinctly shows by his figures; whereas if they were openings, they would then be more evident than when the frustule is filled with its endochrome. Mr. Wenham (*J. M. S.* 1856, p. 159) has been unable to confirm the presence of apertures, and writes—"It may be assumed that if such an opening existed it would have something like a structural margin of such a size as to allow its position at least to be visible under the microscope, but not the slightest break can be observed in the laminated structure that the thickened ends display."

Movements and External Cilia.—By continued observation the Desmidieæ are seen to move very slowly onwards, or with an oscillating movement backwards and forwards. This phenomenon is most notable in the long spindle-shaped fronds of the genus *Closterium*; in others it is scarcely, in many not at all, cognizable. Ehrenberg having persuaded himself of the existence of pedal organs or papillæ at the extremities of the fronds of *Closterium*, found no difficulty in explaining their locomotion; but other observers, who deny the presence of such organs, have been compelled to seek some other explanation of the subject. Some have referred the locomotion to the influence of the vital acts taking place within the organism, to the extrication of gas, &c.; others again, particularly of late, have attributed it to the presence of cilia covering the surface. This latter hypothesis is supported chiefly by the Rev. Mr. Osborne and Mr. Jabez Hogg, who represent these organs as covering the fronds of *Closterium*, of *Staurastrum*, and of other Desmidieæ (see page 7, on the Circulation). Mr. Wenham has sought cilia in vain, and attributes the supposition of their existence to an optical illusion. Powerful oblique sunlight, which is found necessary to display the apparent ciliary movement, this observer remarks, "causes a refractive atom to appear elongated as a ray or line . . . . , and this line also to appear to extend over the boundary of a cell-wall or other adjoining body: another cause of deception arises from a large angle of aperture." The possibility of such errors he illustrates by reference to the circulation as seen in *Anacharis*. In those fronds invested with a mucous sheath, cilia on the surface of the lorica could perform no locomotive function, and therefore can scarcely be supposed present. Likewise in the concatenated species they cannot be looked for, since any movements they possess are of that general sort seen in other filiform Algæ, springing from vital action under the influence of light.

Apart from this inconsiderable movement, seen under the microscope, the

Desmidieæ are known to move through considerable spaces. They travel towards the light; appear on the side of the vessel on which the light falls, or rise to the surface and form a pellicle upon it. These, and the analogous fact of their penetrating to the surface of mud in which they have been imbedded, when exposed to light, are phenomena common to the Desmidieæ with other Algæ. "Another proof (writes Mr. Ralfs) of their power of locomotion is afforded by their retiring in some instances beneath the surface when the pools dry up," a phenomenon witnessed also in the case of other plants. Braun (*R. S.* p. 203) casually refers to this kind of motion, dependent on the resumption of vital action. The *Penium curtum* (*Cosmarium curtum*, Ralfs), which grows "in rain-pools which are alternately quickly filled and dried up in the changes of the weather, ascends from the muddy bottom, when the pools fill, in the form of beautiful bright green clouds, produced by the social growth and the very fluid, widely-extended gelatinous investment of the cells." The movement of this plant, it is added, is more active and more regular than that of other Desmidieæ, and "it is a remarkable sight to behold all the individuals in a dish of water in a short time turn their long axes towards the light, and thus arrange themselves in beautiful streaks in the gelatinous mass. Observation likewise shows that it is the younger half of the cell, distinguishable as such for a long time after division, which here turns towards the light."

CONTENTS OF FRONDS.—The contents of the fronds or frustules of Desmidieæ are designated generally by the name of *Endochrome*. This endochrome, we have already remarked, is of a grass-green colour, and contained in a proper sac lining the denser lorica. It is not homogeneous, but presents numerous globules, small vesicles, and many refracting corpuscles; it is commonly not uniformly diffused, but collected in a definite manner, and it either completely fills its sac or leaves it unoccupied at parts, which not seldom are constant in position and aspect. The appearance of the endochrome is modified by age, by external physical circumstances, and by the process of development. Nägeli and Braun describe it as constituting two layers within the primordial utricle, viz. an outer and an inner mucilaginous layer, the latter the thicker of the two.

Ehrenberg, influenced by his belief of the animal nature of the Desmidiaceæ, and by his peculiar hypothesis of their polygastric organization, represented the larger vesicles or globules to be digestive sacs or stomachs, and the smaller green corpuscles, ova. He even exerted his imagination still further, by announcing that in *Micrasterias*, *Arthrodesmus*, and one or two other genera, male reproductive structures are visible. These suppositions it is not necessary to discuss, seeing that they are unsupported by any facts in the structure and œconomy of this family.

The globules and corpuscles of the endochrome of Desmidieæ seem to differ in no respect from those in other Algæ, consisting of chlorophyll, starch, and of oily materials floating in a watery medium. In most species of *Closterium* and of *Tetmemorus*, some large diaphanous vesicles are conspicuous, either disposed irregularly, or more frequently in a single longitudinal series (II. 1, 12, 13). These have the appearance of being distinct cells; and Mrs. Thomas has indeed described two such, of large size, in *Cosmarium margaritiferum*, as "vesicles filled with moving granules." No doubt many of the apparent vesicles are nothing more than vacuoles which, as in other protoplasmic substances, tend to arise in the cell-contents, and may assume a fixity in size and in position.

The several species of *Closterium* and of *Docidium*, and some of *Penium*, present also, at each extremity of the endochrome (II. 2, 9, 14), "a large hyaline or straw-coloured globule which contains minute granules in constant motion." It is seen even in the earliest stage of the frustules, but disappears in dried specimens.

In addition to these structures, distinguishable in certain genera only, Nägeli and others state that a central nucleus exists in all the Desmidieæ, mostly containing within itself a nucleolus. "In *Closterium* (Braun writes) the nucleus with its colourless mucilaginous envelope is maintained in the centre of the spindle-shaped cell by the green lamellæ of contents, arranged radiantly around the long axis of the cell, which lamellæ are interrupted by it in the middle of the cell. In many cases it seemed to be surrounded as by a band, or by a cavity containing water."

Nägeli affirms that "*Arthrodesmus* possesses a small colourless corpuscle on the wall of the cell, which looks like a nucleolus. *Euastrum* also exhibits frequently among the green contents two obscure bodies resembling nuclei, always one in each half, when the division through the middle takes place. These are not attached to the cell-membrane, but lie free in the midst of the cavity: they appear to possess a dark centre (nucleolus) and a clear periphery (enveloping layer?)....In *Closterium* a nucleus lies in the centre which possesses a thick whitish nucleolus within a clear enveloping layer. It is coloured brown by iodine, and wholly resembles the nucleus in *Spirogyra*." Probably the vesicles mentioned and figured by Mrs. Thomas are really nuclei (I. 2, 5).

There is something special in the disposition of the endochrome in very many of the Desmidieæ. On a front view of *Desmidium*, the endochrome is divided into linear portions by a pale transverse line between the angles; and on a transverse view it is seen to send out as many thick rays as the cell has angles. Again, in *Cosmarium Ralfsii* the endochrome is somewhat radiate; but it is in the elongated genera, in *Penium* and *Closterium*, that its disposition is most characteristic. In both these genera the green matter of the endochrome seems condensed, so as to produce broad longitudinal bands (II. 2, 14), technically called *fillets*, which have their continuity always interrupted at the median transverse suture, and in several examples of the genus *Penium* by three cross bands. These fillets are more or less strongly marked in different cases, and, it may be, are constant in number in the same species. Mr. Ralfs (p. 159) tells us that Meneghini considers them of too much importance to be omitted in the specific definition. They may occasionally be useful in discriminating nearly allied forms; but as they are frequently indistinct, or from various causes not readily counted with certainty, he is unwilling to introduce them into the specific characters, except in the absence of more permanent marks of distinction.

Circulation of Contents.—A circulation or rotation of much of the liquid contents may frequently be seen in the Desmidieæ. The *Closteria* afford the best subjects for witnessing this phenomenon, but careful focusing and other microscopical adjustments are always needed to display it. Even Mr. Ralfs had failed to observe it until he watched it in conjunction with Mr. Bowerbank, in *Closterium Lunula* and in *Penium Digitus*.

Since Mr. Ralfs's account was written, much more attention has been bestowed on this phenomenon; and it has been observed by every microscopist who has sought for it. The Rev. Mr. Osborne has particularly studied it, and has come to the conclusion that it is due to ciliary action. "If (he writes, *J. M. S.* ii. 235) I put a specimen on the stage, cover the stage so as to exclude the light, use the parabolic illuminator with the direct light of the sun, in certain focal positions I see what appear to be cilia working evenly and continuously along the whole external margin of the plant. I am inclined to believe that this is not so, that this is some ocular deception, and that these cilia, so seen, are within the outer case. It may be that these cilia are on the external surface of the membranous sac, as well as over the endochrome; more practised observers with higher powers may yet determine that. Of the existence of the cilia throughout the plant there can be no doubt, and no object I have ever seen will bear comparison with this when beheld under sunlight.....It is seldom that I can trace a current up one margin, and round the point down the other; these currents seem to me *as the rule* to pass from the point, when they reach it, down to the centre of the spot where the cilia are seen terminating the endochrome."

In a second part of this communication the writer adds: "I have scarcely failed in one attempt to see the circulation and ciliary motion in the *Closterium Lunula*. I tried today heating a little water, by putting a small bottle in a cup of warm water; the effect seemed to retard the circulation, but to make the globules larger. I have traced it over the whole extent of the endochrome, but it is best seen at the convex side a short way from the edge. I am more than ever convinced the cyclosis is the waving of *attached tongues of cilia*. The specimens are capricious in the results they afford; they show best when the sun has been on the jar for a time. I have watched the movements of the globules in *Vallisneria*, *Nitella*, &c., and they are to me altogether of a different nature to that in the *Closterium*, &c. To my eye there is no real analogy between this circulation and that in the above plants; but there is much more with the branchial action in the mussel." Mr. Jabez Hogg's supplementary notes to Mr. Osborne's paper represent the whole frond as "brilliantly glittering with the moving and active cilia; whilst in the cyclosis numerous zoospores were most actively moving about by the same agency. When the sunlight falling on these little bodies warmed them into life and motion, the rapid undulations produced by the action of the cilia illuminated the whole frond with a series of most charming and delicately-coloured prismatic fringes or Newton's rings. The motion and distribution of the cilia must be seen by the aid of the direct sun-rays and parabola; for although I tried every other mode of illumination, and with Mr. Brooke used Gillett's condenser, yet neither of us noted satisfactorily their situation and distribution until we resorted to the parabola. At the same time the circulation may be most accurately observed to take place over the entire surface of the frond. The stream is best seen to be running up the external margin, just internal to a row of cilia, with another taking a contrary direction next to the serrated ciliary edge of the endochrome; the whole being restricted to the space between the mass of endochrome and hyaline integument passing above and around the cyclosis, but not entering into it."

Another writer (*J. M. S.* 1855, p. 84), Mr. Western, adduces an observation which he believes to confirm the presence of cilia in *Closterium*, and even goes so far as to advance the notion that the circulation in the cells of *Chara*, and, by analogical reasoning, in those also of other water-plants, originates in ciliary movements. In *Chara*, as in *Closterium*, he tells us, he observed "precisely the same appearances, the same rapid undulations, together with the same brilliant coruscations." Dr. Wright, whose contribution in the same Journal (1855, p. 171) we have previously quoted, admits the presence of cilia, and starts the extraordinary supposition that the circulation of the contents of *Closterium* is carried on through canals or vessels, which he describes as marginal, and that it is independent "of a frequent irregular movement of granules of endochrome more resembling imperfect cyclosis."

If our doctrines concerning the physiology of animal and vegetable cells be at all correct, the statements above quoted respecting the ciliary origin of cyclosis, and more particularly the hypothesis of a vascular system, are scarcely or not in any way admissible. We are disposed to attribute the appearances so interpreted to misconception. Dr. Wright's notion of canals or vessels is equally extravagant with that once advanced by Schultze, of the network of sap-vessels in and about the cells of plants, and requires no discussion. The opinion of Mr. Osborne that the currents in *Closteria* and other Desmidieæ are due to cilia, and are not analogous with the in all respects similar currents in the cells of various aquatic plants, is simply an assumption, and one indeed in opposition both to what an unbiassed observation of the phenomenon in the two sets of plants would suggest, and to what comparative physiology would teach. Again, the analogy he suggests between his supposed ciliary cyclosis and the ciliary action of the branchiæ of the mussel will be inconceivable to any one who understands the structure of the branchial apparatus of Mollusca, the distribution of the cilia on the external surface of a mucous membrane, and their office there in providing for the active performance of the respiratory function. Analogy would, indeed, induce us to believe, that if cilia are the motory organs of the cyclosis of Desmidieæ, they are equally so of that in other unicellular Algæ, as well as of that in the cells composing the tissue of compound forms. If so, we might adopt Mr. Western's belief in the existence of cilia wherever a circulation of the contents of cells is visible, did not our opinion of the nature of cells and of the histological relations of their parts deter us from accepting the doctrine at all of the presence of internal cilia within unicellular organisms.

Then, again, we cannot see the necessity of a ciliary apparatus to secure the fluctuating, oscillating or irregular and mostly incomplete movements of the corpuscles within the cells of Desmidieæ. To us such movements are explicable by reference to the changes ensuing in the nutritive processes of the living organism, and to the currents caused by the ever-acting endosmose and exosmose. Moreover, it should be borne in mind how exceedingly minute these molecular movements are; how very inconsiderable the space passed through is; how sluggish, compared with those due to undoubted ciliary activity, the movements themselves are. But in addition to arguments deducible from analogy and general morphology, those put forward by Mr. Wenham, resting on direct observation and experiment, seem to us strongly adverse to Mr. Osborne's hypothesis, and indicate it to be a consequence of optical deception. At a preceding page (p. 5) we have quoted Mr. Wenham's remarks on the deceptive effects produced in viewing objects by oblique sunlight, or by any powerful source of illumination, and by the use of a large angle of aperture; we will here add his comparative observation of the circulation of *Anacharis*. In viewing this, he tells us (*op. cit.* p. 159), "with a large aperture, the chlorophyll-granules traversing along a straight and thin septum (if the position is favourable) appear to project into the neighbouring cell, seeming to pass directly under the line of the cell-wall. Smaller particles will apparently travel within the substance of the cell-wall; and in case of a boundary or single cell, or in unicellular plants, if the surrounding water has nearly dried up, the rim or prism remaining round the exterior (by the way, just the conditions under which Mr. Western made his observation) causes irregular refracted images of the particles of protoplasm to appear *outside* the cell, bearing such a remarkable similarity to external cilia, that the passing shadows may even be mistaken for currents in the water."

Besides the incomplete rotation or circulation of the contents just considered, there is an active bustling sort of movement of minute granules within an apparent globular vesicle situated at each end of the elongated fronds of some Desmidieæ, *e.g.* of *Docidium* and of *Closterium*. The vesicles in question are known as the "terminal globules," or chambers, and would appear to be actually invested with a membrane, and therefore distinct enclosed sacs. In *Closterium rostratum* and *C. setaceum*, the collection of moving granules is at a distance from the extremities, and apparently not contained within a vesicle. In all species exhibiting terminal globules these structures appear in their earliest stage, but disappear when they are dried.

Ehrenberg imagined the supposed retractile locomotive organs to be fixed to these globules, and that the granular movement within them was no other than that of the bases of these organs. Mr. Varley described the chambers as having contractile walls, and the molecules as transparent spheroids measuring from 1-20,000th to 1-40,000th of an inch, sometimes escaping from their chamber and circulating vaguely and irregularly between the periphery of the gelatinous body and the shell. Mr. Ralfs regarded the terminal globules to be peculiar to the Closterina; yet their contained granules seemed to him "to differ in no respect, except in position and uninterrupted motion, from other granules in the same frond." He once saw the motion continue after their escape from the cell. Mr. Osborne (*op. cit.* p. 235) believes the granules to be ciliary bodies. He writes: "At the extremities of the green matter there are certain bodies acting with a ciliary movement within what has been called a chamber, lying towards the point of the membranous sac; certain bodies, apparently of the same kind, separate from the endochrome in a small mass, appearing at the extreme end of this so-called chamber, or at the side close to the end; these also impart a ciliary movement to the water within the sac around them." He adds (p. 239): "When the endochrome is of a rich dark green, I find the chamber at the extremity very plain and defined, with its cilia very active.... As the endochrome gets of a lighter colour.... the chamber becomes smaller and the cilia are barely seen." At p. 236, Mr. Osborne further states, "The loose bodies seen in the chamber of *Closterium Lunula* have very generally cilia, and are, I believe, zoospores; loose pieces of endochrome are sometimes brought round in the current, but these are easily distinguished. I have never seen anything like true cyclosis, *i. e.* molecules in circular movement, within the so-called chamber."

Of the purpose of the moving granules within the terminal globules, the prevailing notion is that they are zoospores. Meyen likened them to the "spermatic animalcules of plants;" and, as above noted, Mr. Ralfs saw them move about as do the zoospores of other Algæ when freed from the enclosing capsule and frond. So far as we can gather from his remarks, Mr. Osborne also inclines to this opinion, which is likewise supported by Mrs. Thomas (*T. M. S.* 1853, p. 37).

We are sorry that we can present no more definite views concerning the nature, characters, and purpose of the terminal globules than those comprised in the foregoing extracts. We find no similar globules in other Algæ, and therefore obtain no guide from analogy; indeed such structures seem to be peculiar to the elongated Desmidieæ—to the genera *Closterium, Penium,* and *Docidium*; we must consequently look to subsequent research to elucidate the question. (See Appendix at end.)

Another sort of internal movement, more prevalent among the Desmidieæ than that last considered, is "*the swarming motion,*" so called, seen either at one or two parts of the frond when mature, or otherwise throughout its contents. Having once commenced, it never ceases, but extends itself, and induces changes in the nature, appearance, and colour of the endochrome; for this loses its grass-green colour, acquires the autumnal yellowish or reddish-brown tint, and a finely granular aspect. When the granules burst through the openings of the suture between the valves, they escape to a distance and still keep up their active movement.

In the genus *Cosmarium* this phenomenon is frequently and readily observed. Mrs. Thomas, in her interesting observations on *Cosmarium margaritiferum* (*T. M. S.* 1855, p. 33), has detailed the following appearances:—"In each half (she writes) the centre was occupied by a vesicle (as it appeared) filled with moving granules, while smaller vesicles were at the four sides (I. 2). The granules did not appear to circulate through the plant, but kept to their own place, which was either a bag or cavity—I could not decide which." In another example "the granules were swarming over the whole plant."

These peculiar movements of the granules are not restricted to this tribe, but are known to occur in many genera of Algæ. Their purpose seems connected with the reproductive process. Mrs. Thomas (*loc. cit.*) refers to it as in some way related with the formation of sporangia; whilst Mr. Ralfs, who speaks of the swarming particles as "zoospores," confesses himself perfectly unacquainted with their subsequent history, although he coincides with Professor Harvey in regarding the phenomenon of swarming as a "strictly vegetable peculiarity."

Reproduction of Desmidieæ.—This function presents itself under two phases, the end of one of which is to multiply or perpetuate the individual plant, whilst that of the other is to reproduce the species. The former purpose is attained by the process of fission, the latter by that of the development of sporangia, and, it may be, by the swarming of zoospores.

The act of self-division is frequently observed, and is in all respects the same process as in the cells of other Algæ, or indeed of any plant. Analogy, and not, indeed, direct observation, suggests as necessary the initiative action of a nucleus to precede the constriction of the soft lining sac of the lorica, *i. e.* of the primordial membrane, which is next followed by that of the harder external coat. The proceeding is varied, in some non-essential particulars, by the figure of the fronds, and also by the circumstance of its own completeness or incompleteness. Mr. Ralfs has well described the fission of *Euastrum* (*op. cit.* p. 4). The narrow connecting band between the two segments of the frond lengthens and is "converted into two roundish hyaline lobules;" these, though at first very minute, increase rapidly in size, and exhibit from their origin the deep constriction characteristic of the mature fronds. The advancing growth of the interposed new formations necessarily pushes further asunder the original segments, which finally become disconnected, "each taking with it a new segment to supply the place of that from which it has separated.... At first the new portions are devoid of colour, and have much the appearance of condensed gelatine; but as they increase in size the internal fluid acquires a green tint, which is at first very faint, but soon becomes darker; at length it assumes a granular state. At the same time the new segments increase in size and obtain their normal figure; the covering in some species shows the presence of puncta or granules, and, as in *Xanthidium* and *Staurastrum*, the spines and processes lastly make their appearance, beginning as mere tubercles, and then lengthening until they attain their perfect form and size. Complete separation, however, often occurs before all these details of development are complete (II. 11, 24, 26). This singular process is repeated again and again, so that the older segments are united successively, as it were, with many generations." Illustrations of this act are furnished, in the case of two species of *Cosmarium*, in the appended plates (I. 4; II. 26), to which the above account will be found equally well to apply.

"In *Sphærozosma* the same changes take place (I. 11), and are just as evident; but the cells continue linked together, and a filament is formed, which elongates more and more rapidly as the joints increase in number. This continued multiplication by division has its limits; the segments gradually enlarge whilst they divide, and at length the plant ceases to grow; the division of the cells is no longer repeated; the internal matter changes its appearance, increases in density and acquires starch-granules, which soon become numerous; the reproductive granules are perfected, and the individual perishes. In a filament the two oldest segments are found at its opposite extremities; for so long as the joints divide, they are necessarily separated further and further from each other. Whilst this process is in progress, the filament in *Sphærozosma* consists of segments of all sizes (I. 11); but after it has reached maturity there is little inequality between them, except in some of the last-formed segments, which are permanently smaller. The case is the same with those genera in which the separation of the cells is complete.... It is obvious that the new portions must arise from the whole of the junction-margin of the original valves; consequently when the junction occupies only a part of the breadth, the new portion will be narrower than the old; but when the junction of the valves is as broad as the cell, the new portion will from the beginning be of the same breadth," and will remain undistinguishable by its size when fission is complete.

Mr. Ralfs goes on to say that, "when the cell is oblong, or only rounded at the extremities, the process, though similar, is less evident; the cell at first seems merely to elongate (II. 11), until it attains nearly twice its original length, when the division commences, and the rounding of the new ends becomes apparent. The tapering cells present but little difference, for the separation takes place before the extremities are fully developed; sometimes these cells separate obliquely, as in *Spirotænia*."

The mode of self-division in *Closterium* has been illustrated by the Rev. Mr. Osborne (*J. M. S.* 1854, p. 57), from whose account we abstract the following particulars:—"I have (he says) watched for hours the process of complete self-division; one-half of the frond has remained passive, the other has had a motion from side to side, as if moving on an axis at the point of juncture; the separation has become more and more ardent, the motion more active, until at last, with a jerk, one segment leaves the other," each having one extremity—the one newly formed along the line of junction of the two segments—much more obtuse than the other. "The circulation of the contained globules for some hours previous to subdivision, and for some few hours afterwards, runs quite round the obtuse end of the endochrome."

Previously to complete separation each segment begins to show a central constriction of its endochrome, which in due time extends across the new frond, and constitutes the median clear space or band.

A true reproductive act is presented by the act of *conjugation*, or *coupling* of two fronds, and by the resultant development of a sporangium (II. 6, 8; XVI. 11, 12, 13, 14). This process consists in the apposition and subsequent intercommunication of the cavities and contents of two cells, which may be free, or otherwise, members of a chain or filament. It is an act not peculiar to the Desmidieæ, but common to them along with the Diatomeæ and Conjugatæ. "In the family Conjugatæ (says Mr. Ralfs) the cells conjugate whilst still forming parts of a filament; but in the Desmidieæ the filamentous species almost invariably separate into single joints before their conjugation, and in most of the species the valves of the cells become detached after they are emptied of their contents." To bring about the necessary apposition, it is usual for the conjugating cells to expand or bulge out on those sides which are to come into union; and whilst this is proceeding, the vesicles or globules increase much in number, and, together with the granular contents, become aggregated about the conjugating part. When contact is complete, an absorption of the opposed walls of the two cells takes place, or the suture of each opens, the endochrome from both is discharged and intermingled, and an orbicular green granular mass, enveloped in a mucous sheath thrown out around it by the conjugating cells, is produced. When the process has proceeded thus far, the original valves are more or less completely emptied of their contents, lose their vitality, and are sooner or later detached, and float away from the sporangium developed.

The formation of a sporangium by conjugation occupies no great time. Indeed, in the case of *Closterium Ehrenbergii*, the Rev. W. Smith tells us that "the discharge of the endochrome and the formation of the sporangia are accomplished with much rapidity, and may often be seen taking place in the field of the microscope; the whole operation not occupying more than a few minutes.... During the formation of the sporangia there appears to be a second development of mucus in the form of rings around the reproductive bodies; this is probably only the effect of the pressure produced by the growth of the sporangia on the mass of investing mucus."

This act of conjugation admits of slight variations in character, determined by the form of the conjugating cells, and by other circumstances peculiar to the tribe, family, or genus in which in it occurs. In the filamentous species of Desmidieæ, the joints, as before noted, usually become separated before their conjugation; and in most instances the old valves left empty after the act of conjugation are almost immediately detached from the sporangium; but in a few species they persist some time afterwards, *e. g.* in several of *Penium*. In *Didymoprium* the separated joints, on conjugating, unite by means of a narrow process pushed out from each, and often of considerable length; through this the endochrome of one cell is transferred into the other, and thus the sporangium is produced within one of the two cells, just as in the Conjugatæ. In *Staurastrum* and *Micrasterias* the contents of both fronds are discharged into a delicate intermediate sac or bag, which gradually thickens, produces eminences, and at last forked spines (II. 25). Again, in *Tetmemorus*, "the process of forming the sporangium (says Mr. Ralfs) is interesting, as it exhibits a striking similarity to the change during the formation of similar bodies in *Staurocarpus* among the Conjugatæ. In *Staurocarpus*, after conjugation, a subquadrate cell is formed, within which the endochrome is collected. The latter is at first of the same figure as the cell, but in at least one species is at length condensed into a compact globular body, and in every species the cell with the contained sporangium finally separates from the filaments with which it is connected. In this separate state I can discover no character by which to distinguish the sporangium of *Tetmemorus* from one belonging to a species of *Staurocarpus*." To quote the same authority,—"In *Penium Jenneri* the conjugating fronds do not open and gape at the suture, as is usual in the Desmidieæ, but couple by small and distinct cylindrical tubes like many of the Conjugatæ......In *Closterium* two fronds unite by means of projections arising at the junction of the two segments, and then the newly-formed portion continues to enlarge until the original segments are separated by a cell of an irregular figure (II. 5, 6). The contents of the fronds being collected in this cell become a dense seed-like mass, which is sometimes globular, resembling the sporangium of *Mougeotia*, and sometimes square, like that of *Staurospermum*. The newly-formed cell is thinner and generally paler than the segments of the fronds; in some species it looks like a prolongation of the segments, and in others these are so loosely attached that their connexion is scarcely perceptible.

The coupling of the fronds generally takes place from the convex margin, but may occur on the concave, or even the convex margin of one frond may couple with the concave of the other."

The Rev. W. Smith (*A. N. H.* 1850) represents the conjugation of *Closterium Ehrenbergii* to be peculiar (XVI. 11, 12, 13, 14). The first phenomenon (he tells us) is an alteration in the granular condition of the endochrome. This, from a light yellowish green, passes to a much darker shade, and the larger granules, or "diaphanous vesicles" of Ralfs, which were originally few in number, and arranged in a somewhat irregular longitudinal series (XVI. 10), become exceedingly numerous and pervade the entire frond. While this change is about taking place, the fronds approach in pairs, approximating by their concave surfaces, and finally coming into such close neighbourhood that their inflated centres are in contact and their extremities slightly overlapped (XVI. 11). In a short time, probably in the course of twenty-four hours, a remarkable change takes place, both in the appearance and condition of the fronds; a mass of delicate mucus is secreted around the approximated fronds; these remove to a little distance from each other, undergo "self-division," and present altogether an irregular oval figure, the outline of which is formed by the periphery of the mucus, the four divisions of the fronds being placed in the middle in a somewhat quadrilateral manner (XVI. 12). During the progress of cell-division, the internal membrane of the cell-wall becomes enlarged at the suture or line of separation, and projects in the form of an irregular cone, with a blunt or rounded apex forming a beak, whose side view presents a triangular outline. This beak becomes filled with endochrome, either by the dilatation or increase of the contents of the half-frond, and the divided frond assumes the appearance of one with two unequal segments (12), being what M. Morren calls "a *Closterium* of two unequal cones." On these membranous expansions, at the concave surfaces of the fronds, and close to the original sutures, there appear, almost simultaneously with the formation of the beaks, two circular projections, which, rupturing at their apices, give egress to the delicate sacs which enclose the endochrome, and which, drawing with them their contents, and meeting with the endochrome sacs emitted through similar projections from the other half-fronds, form, by their connexion, irregular masses, which quickly consolidate and assume the appearance of perfectly circular, smooth, dark-coloured balls, the sporangia of Ralfs and seminules of Morren.

Lastly, we may add, that Siebold (*J. M. S.* 1853, pp. 118, 119) remarks that the conjugation in *Closterium Dianæ*, *C. lineatum*, *C. striolatum*, *C. setaceum*, &c., differs from that in *C. Lunula*, *C. rostratum*, and other members of the family, by dehiscence at the central transverse suture, and the consequent coalescence of the contents of the two cells into a rounded or angular mass,—an observation which tallies with the account presented us by Mr. Ralfs.

Braun (On Rejuvenescence, *R. S.* p. 286 *et seq.*), speaking of conjugation generally in simple cells, gives an elaborate view of the variations the phenomenon exhibits, and arranges them under several heads. Thus among the Desmidieæ "the conjugating cells unite with participation of the external membrane, [and] the reproductive cell is formed [either] through contraction of the contents clothed by the internal cell-membrane, [or] out of the mere contents as a new cell inside the mother-cell." But in the majority of the Desmidieæ, "the conjugating cells, after dehiscence of the outer membrane, unite through the inner; the reproductive cell is formed out of the mere contents as a new cell inside the conjugation-cell." By the first-named mode, "the formation of the reproductive cell is .... not a direct result of the conjugation, but it is formed subsequently in the interior of the conjugation-cell, in the strongly expanded isthmus of this. The delicate internal membrane, with the contents enclosed by it, drawing itself out of the extremities of the double cell, forms a seed-cell, at first cruciate, four-lobed, then bluntly quadrangular, and finally globular, clothed by a many-layered thickened membrane within the persistent four-horned conjugation-cell. From Ralfs's representation, this is most probably the way in which the process is to be understood in *Cylindrocystis* (*Penium*) *Brebissonii*."

The second mode, when the union of the isolated cells is also lateral and parallel, is exemplified in *Closterium Lunula*, in which, according to Morren's express statement, three different membranes take part in the formation of the canal of union,—an inner and an outer cell-membrane, and a membrane (the primordial utricle) immediately enclosing the green mass. The globular reproductive cell formed in the connecting canal is an active gonidium, which begins to revolve even while in the canal, and soon breaks through the gelatinously-swollen membrane of the latter. Very often two approximated individuals divide again and conjugate before they have completely separated, whence result conjugated double pairs.

The third scheme of conjugation, the most widely extended, is itself reduced by Braun to two principal secondary varieties, and to several subsidiary ones. Thus conjugation takes place either in a parallel position or in a crossed (decussate) manner. The former is peculiar to the Closterina; the latter is met with in *Euastrum* and allied forms, and also in many genera formerly united with *Desmidium*. The modifications, in various species, of these plans are well explained in Braun's work, to which we would refer for particulars, as well as for an elucidation of the production of a "really double spore (not two-lobed, as Ralfs terms it)" in *Closterium lineatum*.

The next question which presents itself is, whether the product of conjugation is to be esteemed a spore or a spore-case, *i. e.* a *sporangium*. That the latter is its nature appears pretty clear, and is assumed as a fact by Mr. Ralfs. This authority observes: "The sporangia I consider capsules, and this view seems to be confirmed by the experience of Mr. Jenner, who states that the covering of the sporangium swells, and a mucus is secreted, in which minute fronds appear, and by their increase at length rupture the attenuated covering." In this opinion Siebold coincides; and the Rev. W. Smith (*A. N. H.* 1850, p. 4) represents, on the authority of Mr. Jenner, the bursting of a sporangium of *Closterium acerosum*, and the development of young fronds from its contents.

Braun, in his philosophical treatise (*op. cit. R. S.* p. 133), remarks of the products of conjugation in the Desmidieæ, that "they do not pass, like the swarming-cells of the Palmellaceæ and the reproductive cells of the Diatomaceæ, directly and by uninterrupted growth into the primary generation of the new vegetative series, but persist for a long time in a condition of rest, during which, excepting as regards imperceptible internal processes, they remain wholly unchanged. To distinguish these from the direct germ-cells (gonidia), I shall call them seed-cells (spores). The development of these spores has not yet been observed; but it may be assumed as certain, that they do not pass as such into the primary generation, but produce this at the period of germination, by an internal transformation of their contents, and bring these to light as a new generation with a dehiscence of the old envelope. Certain early conditions observed in *Closterium* and *Euastrum*, namely families of unusually small individuals, enclosed in transparent colourless vesicles, render it even probable that in certain genera of Desmidieæ, a number of individuals are produced from one spore, by a formation of transitory generations occurring already within the spore. The enclosing vesicle is probably the dissolved and swollen-up internal cell-coat of the spore, which holds the young individuals combined for some time after the outer coat of the spore has been thrown off."

Although Braun has, in the preceding account, made use of the term "spore" to express the conjugation-product, yet, in the very admission that, in those Desmidieæ in which only we have any clue to the subsequent history, it produces, not a single individual, as does a spore commonly so called, but a multitude, he essentially agrees with Mr. Ralfs, who prefers to call the body a capsule. We may quote Mrs. Thomas in support of the same view; for she considers the sporangium a capsule, or (*T. M. S.* 1855, pp. 36, 37) "the winter casing of a large number of young plants which escape from it by rapidly knocking against its walls, when these have been loosened by spring warmth, or which grow up as the walls gradually decay in the midst of slimy gelatinous masses." In proof of this opinion this lady appeals to the immense increase in the number of plants seen in the spring beyond what can be explained as the result of self-fission.

In her opinion the sporangium is a capsule (I. 8, 9) filled with zoospores similar to those moving granules, supposed to be such, seen within the full-grown plant, capable, when their fitting time comes, of filling the waters with their countless progeny.

In these accounts there is a pervading harmony; and the truth seems to be that, by the formation of a sporangium, provision is made for the perpetuation of the species through the winter, when the large majority, at least of adult plants, have ceased to exist. The phenomenon is clearly analogous to that of the formation of seeds by herbaceous plants, or of ova by insects and other animals, when the cycle of existence of the parent being is complete, or is put an end to by unfavourable external circumstances.

Braun has expressed the sequence in the phases of existence in the following technical language (*R.S.* p. 133): "In the Desmidiaceæ, the Zygnemaceæ, and in *Palmoglœa*, the transitional generation is divided into a double one, since the last generation does not pass directly into the first, but the first generation of the succeeding cycle is produced as a new structure in the germination; so that we have here to distinguish three kinds of generation of cells,—the commencing generation, the concluding generation, and the intermediate vegetative generations." The last-named is represented by the process of self-fission, which takes place in the perfect plant, and is continued through a long series of individuals.

Between its first appearance and its ultimate development, the sporangium of Desmidieæ undergoes a progressive series of changes; at first it is pale and homogeneous, but soon gets granular, acquires a gradually deepening green colour, and presents vesicles and globules in large number. The envelope, at first very delicate, augments in thickness, and becomes lined by others, whilst its surface either remains smooth or becomes granular, tuberculated, or *spinous*, and the spines themselves in many instances forked or branched (II. 15, 22, 25, 30, 34). Simultaneously with these changes the integument increases in density, and together with its processes acquires considerable firmness and toughness. Moreover, as it advances in age it usually assumes a reddish-brown colour; when this has happened, the sporangium and contents may be presumed to have reached maturity.

Mrs. Thomas (*op. cit.* p. 35) thinks she encountered a mature sporangium of *Cosmarium margaritiferum* in the shape of a many-coated ball filled with granules in the same rapid motion as observed in the full-grown *Cosmarium* (I. 10, 11). "The similarity of the movement (she says) attracted my attention; and I also saw that in one part the enclosing membrane appeared thinner, as if giving way at that spot. On the third morning the membrane had broken and the granules escaped, leaving the nearly emptied case" (I. 12).

Inasmuch as a sporangium may pass successively from a smooth to a spinous condition, it follows that the transitional stages of one species may be mistaken for the final stage of another; hence a difficulty in determining to what plant detached scattered sporangia may belong. It is only, indeed, when these seed-capsules occur in company with the fronds producing them that we are enabled to pronounce decisively by what species they are generated.

As the foregoing account of conjugation and sporangia passed through the press, we met with the valuable paper of Dr. Hofmeister on the propagation of the Desmidieæ and Diatomeæ, translated by Prof. Henfrey from the *Report of the Natural History Society of Saxony for* 1857. This communication tends to clear up the questions of the nature of the sporangia and of the relation of their contents to the propagative process. The conciseness of the description renders abridgment undesirable; and we accordingly present it (so far as it relates to the points in question) as it stands in the *Annals of Natural History* (1858, i. p. 2):—

"The conjugated individuals of *Cosmarium tetraophthalmum* displayed exactly the behaviour which Ralfs has represented and Braun described of those of *Cosmarium margaritiferum*. The *Cosmaria* which had commenced the conjugation process appeared cracked apart at the constricted place in the middle. Into each of the halves of the tuberculated cell-coat of the two mother-individuals extended a continuation of the membrane of the conjugation-cell. This smooth membrane completely lined the interior of the tuberculated half-shells. The contents of the conjugation-cell revealed no definite arrangement; they were mostly accumulated in the middle into an irregularly-shaped ball; in other cases separated into several such balls, part of which extended even into the split half-shells of the mother-cell. With these conjugated individuals, in the same fluid, occurred (very sparingly) particular specimens which bore, in the middle space between the two separated half-shells, a broad, delicate-walled utricle, the circumference of which about equalled that of the two half-cells taken together. The arrangement of the cell-contents in the primary portions of the cell did not appear essentially altered; the contents of the intermediate expansion consisted of a thick coat upon the wall of granular protoplasm with sparingly-scattered chlorophyll. This condition is probably that which immediately precedes conjugation, originating by excretion of new cellulose at the deepest part of the constriction, after the cracking of the membrane and separation of the primary halves of the cell, exactly as in normal cell-division, from which this process can only be distinguished by the omission of the formation of a septum at the narrowest part of the isthmus. Similar phenomena have been observed by Nägeli in *Cosmarium crenulatum*, and by Mrs. Herbert Thomas in *Cosmarium margaritiferum* (scarcely specifically distinct from *C. tetraophthalmum*), only that here the intermediate piece of the Alga did not conjugate with the similar piece of another individual, but, producing tubercles on its outer surface, continued the vegetative life.

"In other conjugation-cells there lay, in the middle part of the conjugation-cell, a globular cell enveloped in a rather thick membrane, of gelatinous aspect, and smooth on the outside (the spore). No intermediate stages could be found between this and the previously-described condition. Experiments, in which an attempt was made to obtain a completion of the less-advanced conjugation under the microscope, all failed. Apparently the conjugation-cell is exceedingly sensitive to any external injury, especially to contact with foreign bodies. Very probably the contents, in the above-described cases, were already abnormally altered, and incapable of further development.

"In other conjugation-cells the young spore displayed a still thicker membrane, covered on the outside with truncate-conical elevations, in which membrane could be detected a composition of two colourless layers. The outer of these layers remained clear and transparent even in the advance to maturity. Its elevations became developed into rather long spines, which forked at the apices into two or four branches. The deeper-seated layer of the spore-membrane meanwhile assumed a dark-brown colour. By rolling under the covering-glass, the tough, colourless, outer layer may be readily stripped from the inner, more brittle, brown layer; then the latter appears covered on its outer surface with slight elevations, similar to those which first appeared upon the young spore. The brown layer of the spore-coat encloses a third, delicate, colourless layer (perhaps the primary membrane of the spore) which immediately envelopes the cell-contents.

"At the beginning of July, the green contents of all the spores appeared conglobated into a spherical mass with sharp outlines, which, lying free in the middle part of the cell, nowhere touched its internal wall. Three weeks later, in many of the spores these contents appeared separated into two flattened ellipsoidal masses; when I cracked the cell by careful pressure, I was sometimes successful in driving out one or both of the masses of contents in an uninjured condition. They could then be recognized beyond all doubt as primordial cells; bodies destitute of a solid cell-membrane, having a thin coat of protoplasm which 'bubbled' out in water, to which adhered a thick investment, coloured bright green by numerous imbedded chlorophyll-granules, surrounding a central cavity filled with transparent fluid. The fluid contained in the spore in which the two primordial cells were immersed, was not colourless, but rendered turbid by numerous immeasurably small granules exhibiting molecular motion. In August each of the ellipsoidal primordial cells had divided into two globular cells, of similar character to the mother-cell. Towards the end of September, some of the spores exhibited another such division, so that they then contained eight, not globular, but strongly flattened primordial cells. Most, however, passed through the winter-rest unchanged, during which the majority died. At the beginning of April of the next year, the spinous, transparent, outermost layer of the coat was more or less completely decayed on all the spores, even on those which were still to be recognized as living by the vivid green colour of the contents. All the spores still alive contained at least eight, many sixteen daughter-cells, all very strongly flattened, almost discoid. In several spores the outline of the daughter-cells was no longer circular, but displayed two shallow lateral notches. The still-existing, brownish, inner layer of the spore-coat was now seen to be softened; it no longer exhibited its former brittleness, and it was difficult to crack it by pressure. Daughter-cells whose lateral constrictions were most strongly marked, were about half as large again as the circular, whose diameter about equalled that of the isthmus of the former, and they almost entirely filled up the cavity of the spore. When these were pressed out from the crushed spore, their form and size agreed almost exactly with that of *Cosmarium Meneghinii.*

"I saw similar phenomena in the spores of *Cosmarium undulatum* (Corda), in which the investigation is rendered very difficult by the minute size, and which, cultivated for some months in my room, entered abundantly into conjugation. In this, again, I observed the contraction of the green contents of the cell into a globule occupying the central part; the division of this ball into two, four, eight, and sixteen spherical masses; finally, the transition of these daughter-cells of the last generation from the form of circular lenticular bodies into two-lobed ones like the mother-plant. Here the young *Cosmaria*, whose diameter amounted to scarcely $\frac{1}{5}$th or $\frac{1}{4}$th of that of the mother-plant, were set free by the very gradual solution of the membrane of the spore. A similar process very probably occurred in *Cosmarium tetraophthalmum*, but could not be observed there, from the circumstance that all the materials had been used up in the investigation.

"These facts place it beyond doubt that the contents of the spores produced by the conjugation of two individuals of *Cosmarium*, are transformed by repeated binary division into eight or sixteen daughter-cells, which assume the form of the mother-cell, and finally become free by the solution of the wall of the spore. Such behaviour of the spores had indeed been rendered probable before, by the discovery of the vesicular structure observed by Focke and Ralfs, which enclosed a number of small *Closteria*, for the most part beginning to divide. But the certainty which can only be given by direct observation of the development was altogether wanting.

"The development of four daughter-cells in the interior of spores produced by the conjugation of two individuals (with participation of the whole of the cell-membrane), has been demonstrated by Alex. Braun for the Palmellacean *Palmoglœa macrococca*, Kütz. (?)."

Sporangia are the only portions of Desmidieæ of past eras which have been preserved to us in a truly fossil condition. Ehrenberg discovered certain orbicular and spinous bodies in flint, some of which he referred to the genus *Xanthidium* among the Desmidieæ, and others to *Pyxidicula* among the Diatomeæ. However, as Mr. Ralfs remarks (p. 13), this association is, no doubt, erroneous, since in true *Xanthidia* the cell is compressed, bipartite and bivalved, whilst in these fossils it is globose and entire, and there can be no doubt that they are fossil sporangia (XVII. 506 to 515).

To quote Mr. Ralfs's account (p. 13)—"The fossil forms vary like recent sporangia, in being smooth, bristly, or furnished with spines, which in some are simple, and in others branched at the extremity. Sometimes, too, a membrane may be traced even more distinctly than in recent specimens, either covering the spines or entangled with them. Some writers describe the fossil forms as having been silicious in their living state; but Mr. Williamson informs me that he possesses specimens which exhibit bent spines and torn margins, and thus wholly contradict the idea that they were silicious before they were imbedded in the flint."

Another mode of propagation is presumed to take place by means of the active molecules seen within the fronds of Desmidieæ—in other words, by zoospores, as happens in many families of Algæ. M. Morren advanced this notion, and imagined the minute particles which he denominated "propagules," to be at once transformed into small fronds. Mr. Ralfs countenances the opinion so far as to say that the escape of the granular contents of the mature frond is probably one mode of reproduction. He, however, likewise regards (as Prof. W. Smith observes) the swarming of the granules as identical with the movement of the zoospores, and confesses to his ignorance of the history of the motile granules after their escape. But we perfectly coincide with Prof. Smith that the swarming of the granules within a mature frond is in most cases "a disturbance attendant upon the decay of the granular mass," and not a phenomenon connected with reproduction. Still our acquaintance with the swarming granules, particularly after their escape from the frond, is so imperfect that it is useless to speculate on their functional purpose.

Ehrenberg, to carry out his hypothesis of the animal nature of Desmidieæ, and to assimilate their organization with that he attributed to other Polygastrica, represented the larger oil-vesicles and starch-grains to be either stomach-sacs or ova,—at one time the one, at another the other, in a purely arbitrary fashion. Some again of the more transparent or refracting vesicles were, with no shadow of reason, called fecundating or spermatic glands. An attempt to show the error of such an hypothesis of internal organization would be futile and uncalled for at the present day.

HABITATS, DISTRIBUTION, APPEARANCE IN MASSES, AND VITAL ENDOWMENTS OF DESMIDIEÆ. VEGETABLE NATURE AND AFFINITIES. MODE OF COLLECTION.— The Desmidieæ live in fresh water, in ditches and ponds, and rarely in streams, except when these are very sluggish. They will often rapidly appear in a recent collection of water, and are not destroyed when the pool is dried up, as their reappearance immediately after a shower proves; nevertheless, ponds which do not dry up during the summer, and pools in boggy ground, are richer in these organisms, provided the water remains sweet. To quote Mr. Ralfs's experience—"The Desmidieæ prefer an open country. They abound on moors and in exposed places, but are rarely found in shady woods or in deep ditches. To search for them in turbid water is useless; such situations are the haunts of animals, not the habitats of the Desmidieæ, and the waters in which the latter are present are always clear to the very bottom." They no doubt inhabit the fresh waters in all parts of the globe, for they have been found wherever sought in each hemisphere. Still the several genera and species are not universal, for, as in the case of higher plants, some species are peculiar to one country, others to another; and in the same country the presence and prevalence of any one species will be determined by the physical features of localities, by the nature of the soil, and the like. The distribution, however, of the Desmidieæ has not been inquired into so fully as to justify any attempt to lay down special laws.

Oftentimes in small collections of water, Desmidieæ of the same or of various species and genera multiply to such an extent as to colour the water, and in the case of the filamentous species, to appear in filmy masses on the surface or at the bottom of the pool; still this enormous multiplication, and the coloration of the water they inhabit, are far less frequent in the case of the family in question than with others—for instance, the Eugleneæ, or even the Diatomeæ.

Mrs. Thomas (*op. cit.* p. 36) has described the green masses formed by *Cosmarium*, which during summer and autumn "would float to the surface, rapidly disengaging oxygen as the sun shone on them, and sinking again to the bottom with the coolness of the evening. Later in the year, masses would adhere to the inner surface of the bottle in the form of a thin pellicle, or collect in slimy masses, which appeared to dissolve with the warmth of the coming spring. The green colour changed to that of a reddish yellow; and it might have been thought that all was dead, did not the microscope show the same beautiful green, both in young and full-grown plants, together with much bright red and brown, apparently the casings of the sporangia. . . . . Large *Cosmaria* still in active motion (the remains of the mature growth of the preceding summer) lay imbedded in the mass, when a small portion was separated for microscopic observation, as well as clusters of young ones (I. 13, 14). When the bottle had remained more than a year untouched, except for change of water, these masses increased in leathery hardness; green life was not extinct, but became feeble in colour, and too much changed to warrant further observations, while a small portion placed in another bottle, and more freely exposed to the light, multiplied with great rapidity."

Many of the vital endowments of the Desmidieæ have already been described: we have noted their process of reproduction and of growth, the molecular and circulatory movements within them, their slight locomotive power; but besides these, there are others requiring to be mentioned: for instance, their powers of secretion are highly pronounced;—the production of firm envelopes to fronds and sporangia; the formation of starch-grains, of colouring matter, and of oil-globules within; the exhalation of oxygen from the surface,—a respiratory act; and lastly, their ability to resist decomposition.

The Desmidieæ serve as food to many sorts of small aquatic animals, to the Rotifera, to various Annelida and small Crustacea, and to the freshwater Mollusca. They are supposed also to preserve the freshness of the water, and by the oxygen they exhale, to furnish the vital air necessary to the respiration of the aquatic animals found with them. They are subject to destruction not only in the way of supplying food to animals, but also by disease. For instance, Cohn has shown (*Entw. d. mikr. Alg.*) that the *Closteria* are attacked by a microscopic unicellular fungus, called *Chytridium*, the spores of which affix themselves on the integument, and on germinating, penetrate the cavity of the frond by their delicate fibres, and induce a progressive breaking-up and absorption of the contents, until nothing but the empty hull of the plant remains.

Mr. Ralfs has the following remarks (p. 13):—"In all the Desmidieæ, but especially in *Closterium* and *Micrasterias*, small, compact, seed-like bodies of a blackish colour are at times met with. Their situation is uncertain; and their number varies from one to four. In their immediate neighbourhood the endochrome is wanting, as if it had been required to form them, but in the rest of the frond it retains its usual character and appearance. I cannot satisfy myself respecting the nature of these bodies; but I believe them to arise from an unhealthy condition of the plant, or else to be parasitic." With respect to the views expressed in this extract, we are disposed to think Mr. Ralfs right in his conclusion that the black bodies he met with were parasitic; and on comparing his account with the figures and description of the parasitic *Chytridium* in Cohn's memoir (*Entw.*), it seems to us highly probable that the globules referred to were no other than the spores of that microscopic fungus.

For a long time discussion was rife respecting the animal or the vegetable nature of the Desmidieæ. That it was the former was the prevailing notion until within the last few years, when the improvements in the microscope, and the more extended and accurate knowledge of the features of vegetable life in its simplest manifestations, rendered this opinion no longer tenable, and at the present day it may be considered exploded. It is unnecessary, therefore, to go minutely into this question; for it will suffice to indicate the most striking distinctive characters, especially those which rest upon the affinities of the family under consideration. Those readers who would see the point fully discussed will do well to refer to Mr. Ralfs's admirable monograph, to which we, and others also, resort as to a mine, for the materials to build up a history of the Desmidieæ.

An old argument advanced by Ehrenberg for the animality of the Desmidieæ, was, that they had a power of voluntary movement like animals. Without staying to consider the loose and unphilosophic use of this term voluntary, as applied to the motion, whether in the Desmidieæ or in the simplest animal existences, its occurrence can be no proof of animal life, seeing that it is exhibited by acknowledged plants, and in a still more marked manner by their spores. Moreover, such movements are doubtless effected by cilia, both in the animal and vegetable world alike, and are likewise determined by the vital processes going on within and also without these simple organisms, in relation with external media and with surrounding physical conditions. Siebold, quoting Nägeli's opinions, says (*J. M. S.* i. p. 120)—"The slow turning, and at the same time rare movements of the *Closteria* (the genus in which motion is more evident), present no character of spontaneity; these motions are merely the consequence of an active endosmosis and exosmosis, by which the water immediately surrounding the *Closteria*, and consequently themselves, are put into motion." Again, as Mr. Ralfs remarks, the motive power is less in degree than in the Diatomeæ.

Cell-multiplication by fission or transverse division, enumerated by Ehrenberg as an animal peculiarity, is now so completely established as a vegetable phenomenon, that it can claim no consideration when the question of the actual affinities of a disputed organism is to be solved. And equally undeserving of critical examination at the present day is the complex animal organization attributed by the Berlin microscopist to the fronds of Desmidieæ. Concerning the apparent sac containing the moving particles in the *Closteria* and in other genera, regarded by Mr. Dalrymple as a vegetable peculiarity, Mr. Ralfs observes, "I confess I am unable to refer to any example in other Algæ of terminal globules like those present in the *Closteria*, but neither can one be found amongst animals; and if in some respects they have an analogy with organs belonging to the latter, in others they agree better with vegetable life." On another argument raised, the same author remarks, "The contraction of the internal membrane of the *Closteria*, or the expulsion of their contents on the application of iodine or other reagents, cannot be relied upon as a satisfactory test for determining their nature; for the blandest fluids will in some cases (both among recognized Algæ and the *Closteria* themselves) occasion violent action." On the other side of the question, the act of swarming, the emission of actively motile germs (presumed in this family), the presence of starch and of chlorophyll, the chemical relations between these substances, and also with the oily matters formed in the fronds, the exhalation of oxygen in sunlight, and the absence of azotized material in their chemical constitution furnish reasons for arranging the Desmidieæ with plants. Besides these reasons, others are found in the general form and in the modes of propagation being precisely analogous with those in admitted unicellular Algæ. Their intimate affinities with Algæ are shown by the fact that Meneghini and Kützing placed *Merismopœdia* among the Desmidieæ, and that Braun refers the two genera *Scenedesmus* and *Pediastrum*, included by Ehrenberg himself in the family in question, to the Palmellaceæ. The process of conjugation, which has been often appealed to as a characteristic of plant-life, would appear, however, to be, in exceptional cases and under peculiar modifications, also an animal phenomenon, and therefore inapplicable as a test.

Meneghini, who contends for the animality of the Diatomeæ, has pronounced (*R. S.* p. 497, 1853) the opinion that—"The *Closteria* and Desmidieæ in general are plants, and not animals. In the actual state of science we are compelled to admit this proposition. The organic structure, the physiological phenomena, the history of their development, the chemical materials they contain, manifest in these beings a perfect correspondence with others, which in every point of view correspond with the abstract idea of a plant. But what they present in common with other beings evidently animal, is merely an appearance, or at the most, a resemblance in external form. Ehrenberg was misled by this appearance, and, guided by this fallacious similitude, thought that he discovered in the Desmidieæ the same organic peculiarities which proved the animality of other beings."

Respecting the affinities of the Desmidieæ, Mr. Ralfs states that, "on one side, they are allied to the Conjugatæ (Zygnemeæ) by similarity of reproduction, and on the other to the Palmelleæ, by the usually complete transverse division, and by the presence of a gelatinous investment. Indeed the relation to the latter is so intimate, that it is difficult to say to which family some genera belong. . . . Some species of *Scenedesmus* may be allowed to have an almost equal claim to rank with either." Again, they are related to the Diatomeæ by similarity in the reproductive process.

In Ehrenberg's system of Polygastria, the *Closteria* were placed together as a distinct family, under the name of Closterina, whilst all the other genera of Desmidieæ were ranged as a section of the Bacillaria. This separation, based as it was upon presumed structural peculiarities, is no longer accepted by microscopists, who cojoin *Closterium* with the several genera included in Ehrenberg's section Desmidiacea in one group—the Desmidieæ.

The division of this family proposed by Mr. Ralfs is made according as—1. The plant forms an elongated jointed filament (by incomplete division of its cells); or—2. The frond is simple, from complete transverse division, and distinctly constricted at the junction of the segments, which are seldom longer than broad; sporangia spinous or tuberculated—rarely, if ever, smooth; or—3. The frond is simple, as above, generally much elongated, never spinous, frequently not constricted at the centre; sporangia smooth; or—4. Cells elongated, entire, fasciculated; or—5. The frond composed of few cells, definite in number, and not forming a filament.

This last section is so exceptional in general characters, and especially in the mode of reproduction, that Braun detaches it from the Desmidieæ and associates it with the Palmelleæ. In this plan we coincide, and have therefore treated separately this last section of Mr. Ralfs, comprehending *Pediastrum* and *Scenedesmus*.

Kützing (*Species Algarum*) includes the Desmidieæ in his subclass Malacophyceæ, suborder Chamæphyceæ.

Mr. Ralfs enumerated 20 genera; viz.—In Sect. 1, *Hyalotheca, Didymoprium, Desmidium, Aptogonium, Sphærozosma.* Sect. 2, *Micrasterias, Euastrum, Cosmarium, Xanthidium, Arthrodesmus, Staurastrum, Didymocladon.* Sect. 3, *Tetmemorus, Penium, Docidium, Closterium, Spirotænia.* Sect. 4, *Ankistrodesmus* (*Rhaphidium*). Sect. 5, *Pediastrum, Scenedesmus.*

When compiling his systematic work, Kützing appears not to have seen Mr. Ralfs's monograph, but only his detached papers in the Magazines, and consequently was unable to compare the genera established by the English author with those described by himself. The consequence is that Kützing describes several genera not admitted by Mr. Ralfs, who has otherwise disposed their representative species, disallowing the supposed distinctive generic character. Nevertheless it seems desirable to enumerate the additional genera of Kützing, since several are new (unnoticed by our English authority), and derived from the papers of Ehrenberg or of other observers, or from his own researches. Those instituted by Ehrenberg were introduced in our last edition.

The additional genera are:—*Trochiscia* (K.), *Tetraedron* (K.), *Pithiscus* (K.), *Stauroceros* (K.), *Polysolenia* (E.), *Microtheca* (E.), *Polyedrum* (Nägeli), *Zygoxanthium* (E.), *Phycastrum* (K.), *Asteroxanthium* (K.), *Stephanoxanthium* (K.), *Grammatonema* (Agardh), *Bambusina*• (K.), *Isthmosira* (K.), *Spondylosum* (Brébisson), *Eucampia* (E.), *Geminella* (Turpin), *Monactinus* (Corda), *Staurogonia* (K.), *Sphærastrum* (Meyen), *Sorastrum* (K.), *Cœlastrum* (Nägeli), *Rhaphidium* (K.), *Oocardium* (Nägeli).

The value of the several genera instituted and their characteristics form the subject of the systematic history of the Desmidieæ by Mr. Ralfs in the subsequent portion of this treatise.

SUBFAMILY PEDIASTREÆ.

(Plate I. 37 to 69. Plate II. 19, 36, 37.)

This includes the genera *Micrasterias* and *Arthrodesmus* of Ehrenberg, the *Pediastrum* and *Scenedesmus* of Ralfs, Kützing, and others; and, in addition to these two, to follow Nägeli's classification, *Sorastrum*, *Cœlastrum*, and probably also *Sphærodesmus*.

At the time Mr. Ralfs wrote, much uncertainty prevailed respecting what should be considered characteristics of species, and what were the modes of propagation; and it is much to be regretted that, although some of the difficulties and doubts are removed, our knowledge of these microscopic Algæ is far from complete.

Ehrenberg, in harmony with the general views of organization he had adopted, placed *Micrasterias* and *Arthrodesmus* among the Desmidieæ, in the class of Polygastric Infusoria, and described the existence in them of ova, stomach-vesicles, and seminal glands. Yet he was unable to point out one single feature really indicative of their animal nature, even locomotion being unrecognized. Indeed, among those who might be inclined to follow the distinguished Berlin naturalist in attributing an animal nature to most of his Polygastria, the generality would hesitate, in face of the many intimate homologies, structural and physiological, between the Pediastreæ and admitted Algæ, to predicate it of that group of organisms.

Figure, Composition, and Contents of Cells.—The individual cells among the Pediastreæ do not exist isolated and independent, but are united together in a frond, in determinate number and in a definite arrangement for each genus. In all the species they agree in having a membranous wall like the Desmidieæ and Palmelleæ. We confine ourselves, it should be understood, in noting the figure of the cells, to the mature phase or stage, which, although but one of several known phases, is that most marked, best understood, and most perfect.

The cells of *Scenedesmus* (*Arthrodesmus*, Ehr.) (I. 37 to 43) are entire, oval, oblong, or fusiform, with their ends either rounded or pointed. Their length is from two to four times their width or thickness, and they are spherical on a transverse section. They exhibit no constriction or suture at the middle, neither in their wall nor in their endochrome, and in these particulars consequently differ from the cells of true Desmidieæ. The membrane is frequently drawn out in the form of straight or curved spines; this happens usually only with the cell at each end of the chain (I. 40, 41); but in a few cases, other cells nearest to the outer ones become also armed with spines (I. 42). When this extension to the other cells occurs, Nägeli remarks that the spines do not appear on both the superior and inferior extremities of each cell, but only on the upper of the one, two, or three next within the one terminal cell, and on the lower extremity of the same number within the other terminal cell (I. 42). It is rare that the central cells of the chain are armed, and even when this occurs it is only with short spines. In addition to a spine, or, as may happen, a pair of spines from the upper and lower extremity, the end cells at times have a third spine standing at right angles from their sides (I. 41).

The cells of *Pediastrum* are considerably compressed, so that when aggregated they form a flattened tabular structure (I. 44 to 48, 59 to 69). In figure, as seen from above, they vary according as they occupy the margin of the collection, *i. e.* are peripheral, or are central. The latter are polygonal, frequently hexagonal, and no doubt owe this shape to mutual lateral pressure during growth: the marginal cells have fewer sides, and are frequently irregularly quadrilateral, but their free margin is more or less deeply notched, and therefore bilobed (I. 44, 45, 53, 62). The lobes are usually tapering, and form a tubular process either truncate or acute at the extremity (I. 62). In a few cases the notch is not angular, but curved and crescentic (I. 62); in others again it is deep, angular, and gaping (I. 52, II. 27), and gives the cell an irregular figure; this latter condition is more seen where only a few cells are united together, and where the lobes are not prolonged as processes. In some species, moreover, the lobes are terminated by short hair-like spines.

The notch on one side is not confined to the peripheral cells, but extends, in several species, also to the contained cells of the frond (I. 52, 66); their lobes, however, are not tapering, but sharply truncate. Nägeli instituted a subgenus of *Pediastrum* under the name of *Anomopedium*, the chief characteristic of which is the absence of bilobed peripheral cells (I. 46, 47, 48).

The cells of *Cœlastrum* are hexangular (I. 49, 50, 51), the central ones very regularly so, whilst the peripheral are rounded off on their free aspect in one species, and in another notched and bilobed (I. 54, 55). Those, lastly, of *Sorastrum* (I. 56, 57) are wedge-shaped or triangular, with rounded angles; they cohere by their apices, whilst the base is peripheral, often rather concave or emarginate, and, as a rule, armed at each angle by a pair of short spines. On a lateral view the cells are oblong (I. 58).

There is a pervading uniformity in the contents of the cells of the different genera of Pediastreæ, which consist of the usual vegetable protoplasm, and are spoken of collectively as the endochrome. At first the colour is very pale green, but it becomes deeper with advancing age, and in fully mature or decaying cells is seen to change to red or brownish red, just as the leaves of trees change colour on the approach of autumn. At first, the protoplasm is clear and homogeneous, but in course of time granules appear, enlarge in bulk, and multiply in number. Moreover, each cell presents a single chlorophyll-vesicle, which is least discernible in very young and in very old cells (I. 53 to 58). It is ordinarily seen in or about the centre of the cell, but may occur on one side, as in *Pediastrum Rotula*. Around this vesicle are seen in several species clear circular spaces or globules, recalling those of *Closterium*, varying in number in different cases from two to six (I. 44, 45, 53). In *Pediastrum Rotula*, Nägeli observed two such; in *P. Boryanum* and *P. Selenæa* (I. 44, 45), from two to six; in the species of *Scenedesmus* and of *Sorastrum* (I. 57), one hyaline space. This author likewise represents the relative position of the chlorophyll-vesicle and of the translucent space to be constant in similar fronds. In those made up of two cells only, the chlorophyll-vesicle is placed outside, whilst the clear cavity lies against the partition-wall. In chains of four to eight cells the chlorophyll-vesicle is external relatively to the central cell, and the clear space internal (I. 40, 41),—the position being regulated, not by the partition-wall, as in the Palmelleæ in general, but by the centre of the entire frond. Oil-globules are also contained in the cells; their presence is readily demonstrated by the addition of tincture of iodine, for they continue colourless when the surrounding mass is coloured brown; their position often exhibits much regularity. Unless the chlorophyll-vesicle be esteemed nuclear, no nucleus has been discerned in the cells of Pediastreæ. On one occasion Nägeli saw, in *Pediastrum Boryanum*, the endochrome disposed in a radiating manner around the chlorophyll-vesicle, an arrangement which often obtains in Algæ, and in many vegetable cells where there is a central nucleus.

Number and Disposition of the Cells in the Fronds.—The cells of Pediastreæ are always united together in compound fronds. The number so united, and their mode of combination, differ in the different genera and species.

In *Scenedesmus* the cells are arranged (I. 37 to 43) in single linear series, side by side, united by a mucous hyaline matrix, which is less abundant than in *Pediastrum*. Two, mostly four, and less frequently eight cells are concatenated; and, as a rule, the line of union extends the entire length. Exceptions occur, owing to the junction-surfaces being less extensive, in the form of chains of cells having a zigzag border, every alternate cell being depressed below the normal plane, or in that of an oblique chain, having each member in succession depressed beneath the preceding. Sometimes two rows of eight cells each lie side by side (I. 38), so that the one dovetails into the other by the alternate elevation and depression of their component cells: this may happen in the whole extent of the two coherent chains, or in a portion only of their length at one or other extremity; or one chain may be broken into two segments, each dovetailed to the other chain at opposite ends so as to leave an unoccupied central space. The alternation of the cells in fronds composed of two rows, is the result, according to Mr. Ralfs, of the oblique manner of division. In the genus *Pediastrum* the fronds are generally composed of a larger number of cells than in *Scenedesmus*, disposed in the same plane according to a definite and usually concentric arrangement, and forming compound stellate fronds (I. 52, 53, 62, 66, 67), whence the term *Micrasterias* (little star-like beings) invented by Ehrenberg, and also the second half of the generally adopted term (*Pedi*)-*astrum*.

To distinguish species, Ehrenberg chiefly employed the number of the cells in a frond—both the entire number and that of each concentric circle, together with the number of circles. Succeeding naturalists, however, have pointed out that the number of cells in the same species is subject to considerable variation. Turpin detected the true law determining their number, and Nägeli further illustrated and enforced it. The latter writes that (*Einzell. Alg.* p. 92) "the cells are united 2, 4, 8, 16, 32, or 64 together in a frond. These numbers are always constant in young fronds without exception. In older specimens one or more cells may be lost, and the frond become therefore apparently irregular. These cells do not spontaneously detach themselves from the rest, but die, and are partially or entirely dissipated, as a consequence of injury from some external cause, probably in most cases by small aquatic animals. They occur in all stages of destruction, and when entirely vanished, the vacant space indicates their former position. The cells are aggregated together in a single plane, which possesses mostly a circular or somewhat rounded outline; but in the disposition of the cells there is considerable variety. In the case of 4 cells they are either all in opposition (II. 27), or only 2 in the centre; with 8 cells, one usually lies in the middle, and the other 7 surround it in a circular manner (I. 52); less commonly, 2 are central and 6 peripheral (I. 62); rarely, one occupies the centre with 6 around it in a circle, whilst the remaining or eighth cell is placed on the periphery; and still rarer, the disposition is quite irregular. Where 16 cells are combined, the rule is that there is one in the centre surrounded by an inner circle of 5 and an outer circle of 10. At times, 4, 5, or 6 internal cells are encircled by 12, 11, or 10 outer ones (I. 53, 66, 67), whereby a double ring is produced: more rarely the arrangement is completely irregular. Again, 32 cells are mostly so placed that one central cell has around it 3 circles, the innermost of 5, the middle of 10, and the outer of 16 cells; less frequently, the 3 circles are respectively composed of 5, 11, and 15, or of 6, 10, and 16; occasionally 5 internal cells have 2 outer series, one of 11, the other of 16 cells; or 6 cells are enclosed by 11 and 15, or by 10 and 16; or, lastly, the distribution is partly or completely irregular. In the case of 64 cells, no regular aggregation frequently is observable: sometimes 2 or 3 external concentric series are perceptible, where the position of the inner cells follows no rule; less frequently, the concentric arrangement can be followed to the centre; when this is the case, one central cell may be enclosed by four series respectively of 6, 13, 19, 25, or of 7, 13, 19, 24 cells; or again, 2 middle cells have around them 8, 13, 18, 23, or 7, 12, 19, 24, or 7, 13, 19, 23 cells in four rows; or further, 3 central cells have 8, 13, 18, 22 cells around, and so forth.

"The form of the genus *Pediastrum* has in general a decided tendency to a concentric disposition of the cells. Thus 4 cells combine in 1, 8 in 2, 16 in 3, 32 in 4, and 64 in 5 circles. When this concentric arrangement is disturbed, it occurs more frequently in larger than in small fronds, and more frequently among the central than the peripheral cells."

Braun (*Gen. Nov.* p. 71) has entered much in detail respecting the number and disposition of the cells, and arrived at the same general results as Nägeli. He observes that "the same numerical law is common to all the species [of *Pediastrum*], but the number may vary more or less within the legitimate series, even indeed in one and the same species: the disposition also is liable to variation where there is the like number of cells in the same multifarious species; and this so much the more the greater the number of cells....The legitimate (normal) series, viz. 1, 2, 4, 8, 16, 32, 64, 128, is explained by the binary division which takes place in the formation of gonidia, and which is quickly arrested or continued for a longer period.

"I have no direct observations to show whether specimens consisting of a single cell are generated singly from the parent cell, or, after being developed in company with others, they have become dispersed by some accident, which is very probable. Such specimens, belonging pretty clearly to *Pediastrum Ehrenbergii*, occur everywhere in company with the multicellular fronds of this species. Unicellular examples of other species are, it would seem, very rare. I have seen one such of *P. Rotula*; of some which I think should be assigned to *P. Boryanum*. Bi-cellular specimens I have only observed in the case of *P. Ehrenbergii*: instances of 128 cells have frequently occurred to me with *P. valgum*, and twice with *P. Boryanum*. The other numbers are common, and occur in very many or in all species, or in the majority; certain of them indeed much more frequently than others.

"Numbers divergent from the normal series, whether incomplete or more than complete (supra-complete), are rare, whilst very divergent ones are very rare. The former have their origin in the process of fission and the formation of gonidia, when one or other segment in the penultimate division remains undivided, or divides once too often. Thus in *P. Boryanum*, specimens are occasionally found having 15 instead of 16, 31 for 32, 63 for 64 cells, or on the contrary, 17 for 16. Examples of 65 in lieu of 64 cells have occurred to me in *P. asperum*. The latter, *i. e.* those numbers widely divergent, may originate, if in the earlier division of the cytioplasm [protoplasm] some segment is, as it were, passed by, and subsequently enters again in the series of segmentation. In this way the numbers entering into the series 3, 6, 12, 24, 48, examples of which are at hand, may be explained. Three cells have been met with by me in *P. Ehrenbergii*, and more frequently 6, both in this species and in *P. Rotula*;....24 cells, once, in *P. asperum*."

Braun adds that, if any person should doubt that the number of cells differs in the same species, he has only to inspect collections made in the same place and living under like conditions, and to note the unequal forms produced from the same parent individual, and lastly, to remark the analogy presented in other allied genera, *e. g. Scenedesmus, Sorastrum,* and *Cœlastrum,* to convince himself of the fact.

Moreover, as shown by Nägeli, when the number of cells is the same in a frond (*cœnobium,* Braun), their arrangement varies considerably, tending more and more to irregularity as the cells are more multiplied. "The normal and most frequent disposition is orbicular, the cells being arranged, according to their number, in one or several concentric circles, around either a single central cell or none at all. Where two cells are placed in the centre, the circles around incline to an elliptic figure; from this a transition to an elongated form still more aberrant from the orbicular type is indicated, in which the elongate-elliptic circles surround several intermediate cells placed in single or double longitudinal series. By the less regular concentric or the entirely confused disposition of the cells, the elliptic form passes at length into others still more abnormal, such as reniform, panduriform, cuneiform, &c., all which agree in having 64 or 128 cells. The regular concentric arrangement is moreover deranged by the occasional intercalation of cells referable to no one of the circles; and lastly, owing to an incompleteness of the circles of cells, they become so connected one with another, that a spiral disposition is the result, which, although abnormal in every species, is in some specimens constructed with wonderful regularity. All these various arrangements arise from the manner in which the motile gonidia are disposed and marshalled in their first stage; for these are distributed within the parent depressed orbicular cell, according to the laws of juxtaposition, in a plane."

Another peculiarity in the disposition of the cells in the fronds of *Pediastrum* is, that sometimes, instead of being all in juxtaposition, so as to form an unbroken congeries of cells, or, in the language of Nägeli (*op. cit.* p. 94), instead of being parenchymatic, apertures or interspaces are left between them (I. 53). This is most seen where the inner cells are more or less bilobed, so that an opening subsists between the lobes of each cell; but similar apertures may likewise occur at the angles where the cells come into contact. When the position of the cells in the table is regular, that of the foramina is so also. *Pediastrum Selenœa* with 16 cells has, as a rule, 6 large and 8 small openings; the large are bounded by 3 cells, the small by 2; the small spaces are sometimes absent, when the large become very evident. Fronds of the same species, having 32 cells, display usually 11 larger interspaces lying betwixt 3 cells, and 18 smaller enclosed between 2 cells.

Anomopedium, a subgenus of *Pediastrum,* differs not only in its peripheral cells not being bilobed, but also in having its cells partially disposed in a double plane (I. 46, 47, 48). The cells which are in the numerical series of 4, 8, 16, 32, and 64, are subject to manifold arrangements, and frequently aggregated quite irregularly. They are mostly so placed, that in one, two, or even three directions, they can be clearly discerned to be in parallel straight rows. A concentric disposition is quite exceptional; not unfrequently, instead of all the cells occupying the same plane, some form a partial second layer upon the other about the middle.

In *Cœlastrum* (I. 50, 51, 52) the hexangular cells are so arranged that they form a hollow, globular, areolar frond. *Cœl. sphœricum* consists of 25 to 40 cells, which compose a lamina perforated by 3, 4, 5, 6, 8 angular meshes (areolæ) somewhat larger than the cells themselves, and from 13 to 22 in number. *Cœl. cubicum* consists of 8 cells united in a cubical form, hollow inside: on each side are 4 cells enclosing a quadrangular aperture.

Lastly, in *Sorastrum* the wedge-shaped or cordate cells (I. 56, 57) are all in close apposition and form a globular frond. The cells in the typical species, *S. echinatum*, are 8 or 16 in number, and so arranged that all their apices converge towards and meet in the centre of the frond.

Sphærodesmus, which probably is rightly accounted one of the Pediastreæ, is named, but not described, by Nägeli; we are, however, informed by Braun (*Gen. Nova*, p. 70, in foot-note) that its fronds are composed of 4 spherical cells closely aggregated in a rhomboidal form.

Development and Growth.—*Scenedesmus* multiplies by fission, as Ralfs believed, in an oblique direction, but according to Nägeli, parallel to the long diameter of the cells. The former adopted his opinion from the features of biserial chains; but the latter interprets those appearances by the simultaneous occurrence of longitudinal and of transverse fission (I. 37, 39).

The process of self-division commences generally at the same period in each cell of the frond (family, Nägeli), and proceeds with so great rapidity that its intermediate stages are unobserved. One of the two terminal cells (I. 39), or, in an eight-celled, probably the two, sometimes remain for awhile undivided. The cell separates into two, then each of these again into two others, and at times this act of subdivision is repeated a third time. By a more prolonged act of segmentation of the cell-contents, the result is a number of minute cells which arrange themselves in rows of two, four, or eight, and thus form miniature fronds which ultimately escape the parent-cell by rupture. Occasionally, adds Nägeli, the young fronds are connected together by mucus, formed by dissolution of the parent cell-wall. Development takes place in parallel planes, although by their increase they become mutually compressed and irregular, and the chains curved prior to their discharge.

This production of macrogonidia and their cohesion into fronds has not been seen by Braun, and is, in his experience, an exceptional phenomenon (*Gen. Nova*, p. 67).

When Mr. Ralfs wrote his work on the Desmidieæ (in 1848), he had to confess himself altogether ignorant of the modes of reproduction both of *Pediastrum* and *Scenedesmus*. He, however, described self-division of the cells in both genera, but rightly regarded this process as one not of development, but of vegetative increase and repetition. On this subject he remarked (*op. cit.* p. 182),—"I have not seen the cells during the process of division, but I am informed by M. de Brébisson that it takes place at the notch, in the same manner as in other Desmidieæ: hence the cells in each circle are connected at their ends, like those of the filamentous genera. I do not, however, understand in what manner the additional circles are formed, nor why the numbers in each circle are so constant."

Nägeli, likewise, was equally ignorant of the propagation of *Pediastrum*, but thought it highly probable it resembled that of *Scenedesmus*. The number of cells in a table or frond, indicated to his mind its production by a series of fissions in the power of two; and he presumed that a new frond was generated within a parent cell by division of its protoplasm, just as in *Scenedesmus*,—a supposition supported by the fact that the entire young fronds are not larger than the single cells of mature specimens, that like these they are composed of the same number of individual cells similarly disposed, and undergo no subsequent segmentation into a larger number.

The more recent researches of Braun are confirmatory of the views of Nägeli (*Gen. Nova*, p. 68). Amid a large number of specimens of *Pediastrum Boryanum* he detected the escape of, in most instances 32, more seldom of 16, and rarely of 8 gonidia, from a parent cell,—the number generally, but not invariably, corresponding with that of the cells composing the mature frond or cœnobium. The collection of gonidia was enclosed by a common envelope, within which they moved actively about for a quarter of an hour before coming to a state of rest, and arranging themselves regularly in a frond (I. 64). This sac is described in the author's work on Rejuvenescence (*Ray Soc.* p. 184) as the vesicular inner layer of the mother-cell. He witnessed this production of gonidia from many, but not from all the cells of the fronds, for it seems to take place in them in succession, and probably in some definite manner, according to their position in the frond. He further describes the development of *microgonidia* to follow the same plan as that of *macrogonidia*, but to differ from the latter in number, size and form, and in duration and cessation of motion. *Macrogonidia* have a subglobose figure, a diameter of $\frac{1}{160}$th of a millimetre; one side hyaline, and scarcely elongated, the other turned towards the periphery of the frond, green, and by-and-by extended and emarginate: no vibratile cilia discoverable on them. They never leave the sac in which they are produced; and the young frond is seen, until the close of the second day, loosely enveloped by a gelatinous layer, which ultimately disappears by deliquescence (I. 64).

On the other hand, *microgonidia* are at first densely aggregated and closely invested by the sac in which they are generated; like macrogonidia they are subglobose (I. 60, 61, 68, 69). After a while the sac is gradually dilated, and, growing more and more in length, forms an acute hyaline beak (*rostrum*) as long as the green portion, which constitutes the rest, or the body, of the gonidium. This rostrum, moreover, is furnished either with a pair of cilia, longer than the body, or with a single cilium. The length of these developed microgonidia is nearly $\frac{1}{100}$th millimetre; the thickness $\frac{1}{250}$th (I. 61, 68, 69). The movement within the sac is at first slow; but when this is fully expanded, it is very active, and continued for an hour and upwards, until the sac is ruptured, and the whole heap of microgonidia escape. The number of microgonidia cannot, by reason of their aggregation and their swarming movement, be easily determined; at least 64 occur in a sac, and most commonly many more, for instance, 128. Of their subsequent history, Braun can give no satisfactory account.

A reference to the same able writer's book on Rejuvenescence (*R. S.*) informs us, at p. 200, that before the formation of the gonidia of *Pediastrum*, the single starch-grain, the nuclear character of which has been above remarked, disappears. From the same source we also obtain a series of illustrations of the development of macrogonidia, of their arrangement in the characteristic stellate frondose form, and of the varieties in the number and arrangement of the component cells, which may be seen in examples of the same species of *Pediastrum*.

The development both of *Cœlastrum* and *Sorastrum* is unknown.

The Pediastreæ are of freshwater habit, living in ponds, on which they frequently form, in conjunction with other small plants, a coloured film or scum. They are also common in turfy pools on moors, and invest the surface of various aquatic plants.

Systematic Position of Pediastreæ.—Mr. Ralfs followed Ehrenberg, Meneghini, and others in placing the Pediastreæ among Desmidieæ; but Corda, Nägeli, and Braun have separated the two as distinct tribes. Indeed, Mr. Ralfs has modified his views since the publication of his monograph, and would treat the Pediastreæ as a subfamily of Desmidieæ. Nägeli (*Einzell. Alg*) arranges them with the Palmelleæ as a distinct group, and in this has the support of Braun (*Gen. Nova*, p. 69). These naturalists point out that the distinctive features between the Pediastreæ and the Desmidieæ, are that the former neither conjugate nor multiply by continued transverse division of their cells in the same direction, each newly-formed segment acquiring all the characters of a complete cell; that, unlike the Desmidieæ, they propagate by gonidia; have but one instead of two or more equally-sized starch-grains and a central nucleus; and that their fronds are not distinguishable into two symmetrical halves. "The Desmidieæ are evidently multicellular, or pseudo-unicellular, from separation of their cells, whilst (says Braun) *Pediastrum* is a true unicellular Alga rendered pseudo-multicellular by the cohesion of the cells. The aggregation of cells in Desmidieæ is always uniserial, filiform or concatenate; the fronds of *Pediastrum* are grouped on a plane of a disc-form or frondose character."

Braun next traces the affinities of *Pediastrum*, and remarks that, although it resembles *Hydrodictyon* in the construction of its fronds (cœnobia) by the connexion of motile gonidia, yet since in *Hydrodictyon* the gonidia are simultaneous, and in *Pediastrum* successional, it is rather an analogy than an affinity which exists between these two genera. However, he admits the correctness of the association of *Pediastrum* with the genera Nägeli indicated, viz. with *Sorastrum*, *Cœlastrum*, *Scenedesmus*, and probably *Sphærodesmus*, and would add to their number the genus *Staurogonia* (Kütz.), the *Crucigenia* of Morren (*Ann. des Sciences Nat.* 1830, p. 404). All these genera agree with *Pediastrum* in the successional formation of gonidia, yet differ from it in other particulars except in the construction of the frond from motionless gonidia. Among other genera, *Polyedrum* may be likened to *Pediastrum* in the form of its cells, but its propagation is unknown; lastly, *Characium* and *Cystococcus* agree with *Pediastrum* in the successional genesis and activity of their gonidia.

To this elucidation of the affinities of *Pediastrum* we have to add the observation of Cohn (*Entwick. d. mikr. Alg.*), of the analogy or affinity in general structure between this genus and *Gonium*.

The division of *Pediastrum* into tribes or subgenera, as proposed by Braun, and the distinction of species of the Pediastreæ in general, will receive due consideration in our systematic account of the family.

II.—OF THE FAMILY DIATOMEÆ OR DIATOMACEÆ.

(Plates IV. to XVII.)

General and External Characters of Diatomeæ.—*Testules or Frustules.—Figure: free, concatenated, and fixed Forms.—Varieties of Filaments and of Pedicels.—Aggregated Frustules.*—The Diatomeæ, Diatomaceæ, or Cymbelleæ, are unicellular organisms composed of two opposite plates or valves, generally convex, and of an interposed connecting third segment, forming together a miniature box of a silicious nature, enclosing a soft organic matter, rarely green, but usually yellowish or orange-brown in colour. They inhabit either fresh, salt, or brackish water.

They were reckoned by Ehrenberg among the Bacillaria, and have in consequence been sometimes described as silicious Bacillaria.

Each individual Diatom enclosed in its silicious envelope is spoken of as a frustule, testule, frond, or bacillum, and in general phraseology as a cell. The first term is that now most in use, whilst "testule" and "bacillum" are words rarely employed, except in the works of Ehrenberg and of his immediate disciples.

A rectangular or prismatic figure most widely obtains in this family; and the angles of junction of the valves are as a rule acute. Deeply notched fronds, like those in Desmidieæ, *e. g. Micrasterias* and *Euastrum*, do not occur; and the production of spines and tubercles on the valves, so common in that family, is rare among the Diatomeæ.

FIGURE.—There is an immense diversity of figure among the frustules, determined chiefly by that of the opposed valves, but in some degree also by the amount of development of the interposed third segment or cingulum (XVI. 23, 24.) This last Mr. Ralfs considers an essential part of every frustule; but Prof. Smith states it to be a secondary, non-essential element consequent on the growth of the organism, and specially developed in relation to the process of self-division. When this cingulum or "connecting membrane" is much enlarged prior to fission, the figure as viewed on this side is considerably changed, and the appearance of a double frustule often occasioned.

Not a few of the Diatomeæ are much elongated and narrow, and from presenting a wand-like figure (IX. 148, 166, 174; X. 184, 185), suggested to Ehrenberg the term Bacillaria to designate the family. However, some species are trapezoid, or square, or nearly so (X. 47, 21, 22), others round like pill-boxes (IX. 131, 181; X. 200, 204), whilst others again are almost globular or spheroid, owing to the great convexity of the valves. Several genera are boat-shaped, scaphoid, or navicular in figure (IX. 139, 135; XII. 5, 6, 8, 48, 43); some are rather oval, egg-shaped, or ovoid; many resemble thin flattened discs—are discoid (XI. 33, 35, 36, 39); many are wedge-shaped—cuneiform, or cuneate; a few are triangular (XI. 43, 45); lastly, some are curved or twisted on themselves, and others assume in certain directions a sigmoid or an undulated figure (IX. 144, 145; XV. 11, 22, 59, 60). Evenly-curved valves are said to be arcuate, such as those of *Eunotia* (IX. 165; XVI. 10, 18), and of some species of *Cymbella* and *Nitzschia*, whilst the peculiarly-twisted valves of *Campylodiscus* (XVII. 517) are saddle-shaped. In *Cymatopleura*, again, the surface of the valves is undulated, and when bent rather sharply at an angle on themselves, the valves become geniculate, as in *Achnanthidium*.

As a rule the frustules of Diatomeæ are symmetrical, and consist of two equal and similar halves; but exceptions to this are found in the Achnantheæ, Cocconeidæ, and one or two other families (IX. 159).

Another variety of frustules is described as winged or alate,—the ala being a smooth expansion in the form of a margin (XIII. 5, 6, 7). The alæ may arise from the margin, and are then said to be marginal, as in *Surirella*, or otherwise from the disc, as in *Tryblionella*, in which they are called submarginal. A further modification of the valves affecting the figure is exemplified in *Nitzschia* and *Amphiprora*, which have a longitudinal elevated ridge extending from one extremity to the other; such ridges are called keels, and the valves keeled or carinated. In the discoid forms two portions are commonly distinguishable, viz. the disc and margin or rim (XI. 31, 35, 38), the one at times separated by a distinct line, and often presenting different sculpturing from the other. The disc moreover exhibits occasionally at its centre a prominence or elevated thickness called an *umbo* or boss. In *Eupodiscus* (XI. 41, 42) tubular horns come off from the surface of the valves, and in *Triceratium* from the angles.

The extremities of some species, *e. g.* in *Nitzschia* and *Pleurosigma*, are extremely elongated, forming long, filiform, tubular processes; and in *Denticella*, *Biddulphia* (II. 46, 48, 50), and *Rhizoselenia* (Ehr.), short tubular processes and spines are produced from the surfaces and margins. These processes are commonly simple, but according to Ehrenberg are branched (ramose) in the genus last cited, and in *Dicladia* and *Syndendrium*. Moreover, very singular hispid and sometimes bifid processes or styles have been noted on the valves of some species of *Goniothecium* (Ehr.), recalling by their figure that of the spines on the sporangia of many Desmidieæ. Other

Diatoms, referred by Mr. Brightwell (*J. M. S.* 1856, p. 106) to the genus *Chætoceros*, have highly developed spines on the valves, besides the two pairs of very long filiform smooth or spinous horns springing from the frustules themselves, or from the interposed cingulum. *Cerataulus* is another genus provided with a pair of long horn-like processes.

Great variety of outline may prevail in a genus, so considerable indeed that an accurate definition is with difficulty laid down, the characteristics shading off through several species, until at length the similarity to an assumed typical form is much diminished, whilst on the other hand an approach is made towards the features of another genus. The like latitude of form prevails also with species, and gives rise to very numerous and frequently perplexing varieties. On this topic Prof. Smith remarks—"While a typical outline of its frustule is the general characteristic of a species, this outline may be modified by the accidental circumstances which surround the embryo during its growth and the development of its silicious epiderm; then, any such aberration of form becomes stereotyped by the process of self-division of the frustule, generating multitudes of others slightly deviating from the normal form." It must not be forgotten that the figure is greatly modified or entirely changed by the position of the valves, whether seen in face or on one side; for each frustule generally presents four planes or sides, and, unless regard be paid to this circumstance, one genus may be mistaken for another, or even each view be presumed a distinct genus. Thus in the genera *Navicula*, *Pinnularia* (XII. 5, 6, 15, 18), and in many others, the frustules are on one aspect boat-shaped, but on the other oblong with truncated ends, or prismatic. In the genus *Triceratium* (XI. 43, 44), the difference of figure is very remarkable according to the side viewed (as presently illustrated). It is therefore necessary to examine a specimen on every aspect it presents: this can generally be effected by the accidental rolling over of frustules under inspection, or can otherwise be brought about by a very slight sliding movement of the thin glass cover upon the slide under the microscope.

Mr. Brightwell thus describes and explains the transitions of form produced by a change in position of the frustules of the genus *Triceratium* (*J. M. S.* i. 248):—"The normal view of the frustule may be represented by a vertical section of a triangular prism. If the frustule be placed upon one of its flat sides, we look down upon its ridge and obtain a front view of its two other sloping sides. If it be placed upon one of its ridges, we have a front view of one of its flat sides, generally broader than long, and of its smooth or transparent suture or connecting membrane. If the frustule be progressing towards self-division, it is then often considerably longer than broad, and when nearly matured for separation presents the appearance of a double frustule."

It would be in vain to attempt to describe all the numerous forms assumed by the members of this extensive family; the representations in the plates of this volume will convey the clearest notions of their diverse outline and markings (see Plates 4 to 17). Great difference unfortunately has existed respecting the sides which should be esteemed primary and afford specific characteristics, and those which should be held as only secondary; and the nomenclature of the surfaces has been equally a matter of dispute and uncertainty. Ehrenberg employed the terms *dorsum*, *venter*, and *lateral surfaces* or *sides*, but so loosely that they do not always indicate homologous portions. Thus he has often called a convex surface the *dorsum*, simply from its convexity, and a concave one the *venter*, on account of its concavity. Kützing attempted a more certain and scientific phraseology by calling those sides which have no central opening (*umbilicus*), but through which self-division occurs, the *primary sides*, and the other two the *secondary sides*, further distinguishing the latter into a right and a left with reference to the frustule when lying on a primary side. The left side is often concave, and the right convex; mostly, however, the two are alike. As a general rule the primary sides correspond with the *lateral surfaces*, and the secondary with the *dorsum* and *venter* in the terminology of Ehrenberg. Mr. Ralfs, in his papers in the *Ann. Nat. Hist.*, used the simple terms '*front view*' and '*side view*,' corresponding respectively with Kützing's names primary and secondary sides. The Rev. W. Smith adopts this nomenclature as the most convenient for the English student, and uses the term '*front view*' to denote the aspect of the frustule when the valvular suture (connecting membrane), or the line along which self-division takes place, is turned towards the observer, and the term '*side view*' when the centre of one valve is directed to the eye. He adds—"Even these terms will require modification when applied to some of the more complex and irregular forms; but in general their meaning will be sufficiently obvious."

It must happen, therefore, from this terminology, that at times a front view cannot be said to exist, viz. when the connecting membrane is obsolete and the opposed valves are closely applied to each other, a suture alone indicating the line of junction.

In size the Diatomeæ vary very greatly; some individual frustules are cognizable by the naked eye, whilst others require the highest powers of the microscope to display them. Even among specimens of the same species great diversity of size prevails,—a peculiarity much determined by the circumstances surrounding a frustule at the period of its development, and afterwards perpetuated through a long series of individuals multiplied by self-fission.

The Diatomeæ exist under three chief forms, as—1. Single isolated free frustules. 2. Frustules attached by a stalk, stipes, or pedicle. 3. Frustules coherent in chains, or aggregated together in ramose tufts by an interposed gelatinous substance. The third form is the consequence of incomplete fission, or of imperfect separation after fission. Incomplete fission and consequent concatenation are observed in *Bacillaria, Meridion, Himantidium, Melosira, Odontidium, Striatella, Fragilaria*, &c. (IX. 131, 167, 171, 175, 176, 177); and the form of the chain or filament produced will be determined by the figure of the individual frustules composing it. For instance, if these be rectangular, then the resulting chain (IX. 171, 172, 176; XIV. 2, 4, 6, 13) is straight, but if wedge-shaped, it is curved or spiral (IX. 177, 179; XII. 21). The extent and degree of attachment of the adjoining frustules differ in different genera; thus, in *Bacillaria* it is very slight, and readily yields, allowing one segment to glide on another, or to separate from it, except at one point, yet at the same time possessing the power of recovering itself. In *Odontidium, Himantidium, Denticula*, and *Meridion* (IX. 177), the mutual adhesion of the several segments is stronger; and after the opposed surfaces have been separated, future adhesion is not effected. In *Fragilaria*, the adherence is more tenacious. In *Diatoma, Tabellaria, Grammatophora, Amphitetras*, &c. (II. 46; XI. 22, 52; XIV. 23), the frustules hang together by a sort of hinge inserted between adjoining angles in a zigzag fashion. In *Isthmia*, this hinge or connecting link attains a greater magnitude, and, in fact, is double. In *Podosira* (II. 45) and in some species of *Melosira* a junction-process is developed from the centre of each frustule in the chain. In other *Melosiræ* and in *Orthosira*, the junction-surfaces are toothed (dentate), and thus hold the adjoining frustules in firm union. In the instance of *Biddulphia* (II. 46, 48), the surfaces in union are curiously elongated at the angles into rounded or horn-like processes, whilst their convexity is crowned by several bristles or setæ. Lastly, in *Eucampia* (II. 43) the junction-surfaces are so excavated, that when the frustules are concatenated a filament is formed, perforated by oval foramina.

In not a few genera, as above mentioned, the attachment is at opposed angles, and a zigzag chain produced; but in *Isthmia* (X. 183) it is peculiar in being indiscriminately made at any part of the adjacent frustule, and thereby produces an irregularly branched filament.

The above examples will suffice to illustrate the characters and varieties of concatenation in the form of filaments, whether straight or spiral; but it is necessary to add that the width of a filament "equals the length of the frustule or valve measured along the suture or junction-line, and that the breadth of the valve denotes the thickness of the filament" (*Smith, Synops.* ii. 6). In those instances in which frustules are connected together by a process or small isthmus acting as a sort of hinge, the concatenation cannot be ascribed to incomplete division only, for the existence of such a process is the result of a special formation which essentially corresponds with the pedicle or stipes of fixed species.

Numerous Diatomeæ grow attached to foreign bodies by a stalk of variable length, and which, although generally simple, is sometimes compound by dividing and subdividing in a ramose manner. Even among the recognized free Diatomeæ, such as *Navicula*, *Pinnularia*, *Nitzschia*, &c., specimens are not unfrequently seen adherent by one extremity, about which they turn or bend themselves as on a hinge; however, in these instances such union is but temporary, and no connecting medium exists. In *Synedra* (X. 184), on the other hand, a bond of union occurs in the form of a little gelatinous conical nodule, resembling very nearly the hinge-like isthmus which binds together the frustules of many genera in a sort of zigzag chain. By the process of self-division it also comes to pass that groups of *Synedræ* occur attached together by the same point, in a fan-like or a stellate form, as in *S. radians*, *S. affinis*, &c. In other species detachment after fission is too speedy to allow of this sort of combination, except of some two or four individuals. The fan-like collection of frustules is said to be flabellate, fan-like, or radiating; and when the component members are curved, they and the bundles they form are described as arcuate. The nodule of attachment occurs in various degrees of development, and attains in this same genus *Synedra* to the dimensions of a pedicle—ex. in *Synedra superba*, and even to branch, as in *Synedra fulgens* and *Synedra pulchella*.

When a stipe branches, it does so normally in a dichotomous manner by the very circumstance of the process of self-division, each new individual produced by that act developing its own secondary pedicle, or pedicel.

This regular dichotomy is instanced in the genera *Doryphora* (XIV. 21), *Cocconema* (XIII. 10), and *Gomphonema* (XIII. 11). In *Licmophora* (XIII. 20), and in one species of *Rhipidophora*, viz. *Rh. Dalmatica*, an irregular branching—essentially dichotomous, however—is met with, and is thus explained by Prof. Smith:—"In *Rhipidophora paradoxa* and *Rh. elongata*, self-division is immediately followed by the separation of the half-new frustules and a dichotomy in the filamentous stipes, while in the present genus the frustules remain for a time coherent, and continue dividing and multiplying on the summit of the pedicel, which becomes elongated and incrassated at each successive repetition of the process.... A branching, or rather longitudinal rupture, of the pedicle takes place at irregular intervals; and the entire organism presents us with more or less complete flabella (fan-like clusters) on the summit of the branches, and imperfect flabella or single frustules irregularly scattered throughout the entire length of the pedicel."

The same authority has the following remark on the process of ramification: he says (I. 75), "When self-division (*i. e.* of the frustules) is completed, the extension of the filament below the frustules is suspended, a joint or articulation is formed at the base of the dividing frustule, and each of the half-new frustules begins anew, in its progress towards special self-division, the secretion of a new joint or internode; and a dichotomy is the result."

The occurrence of the double condition of union of frustules in a concatenate manner and of attachment by a pedicle is illustrated in the genera *Achnanthes* (X. 201, 202), *Striatella* (X. 203, 204), *Rhabdonema* (XIII. 27), and *Podosira* (II. 45). In *Melosira* also, attached species occur; and Prof. Smith inclines to the opinion that all filamentous Diatomeæ are stipitate on their first production. In the second stalked genus cited, viz. *Striatella*, the stalk attains the highest development, but remains slender and unbranched. Between this most developed form and the mere nodules of attachment in the genera *Achnanthes* and *Melosira*, every intermediate phase is encountered. In any one species, however, there is no positive determinate length of the stipes, for this varies according to the idiosyncrasy, vigour, and external conditions affecting the organism; consequently characters derived from the dimensions of the stems can have no specific value.

There is a large section of Diatomeæ in which the frustules are diffused throughout a mucous or muco-gelatinous mass, rarely confusedly, but mostly in a definite manner, usually in thread- or tube-like branches, which normally ramify in a dichotomous fashion, and resemble on a minute scale the tufts formed by many large sea-weeds. This peculiar aggregation is the consequence of the large production and subsequent persistence of the mucus which is thrown out when the system of reproduction, whether by sporangia or by fission, takes place. Histologically, therefore, it is homologous with the pedicles and connecting nodules or isthmi thrown out during the act of self-division, as also with the mucous stratum, which still very often persists when that act is complete, around specimens of *Cocconeis*, *Chætoceros*, *Melosira*, *Fragilaria*, *Striatella*, &c.

The tissue thus composed of mucus and enclosed frustules constitutes what is called (from analogy with the large Algæ and other Cryptogamic plants) the *frond*, and affects various shapes, in some measure characteristic of the genera. Thus, in one of those so-called frondose Diatomeæ, viz. *Dickieia* (XV. 30, 31), it is membranous and leaf-like, and resembles a species of Ulva; in *Mastogloia*, filiform with nipple-like expansions; in *Encyonema* (XIV. 22), *Homœocladia* (XIV. 37, 38, 47, 49), and *Schizonema*, filamentous and more or less branched; in *Colletonema subcohærens*, globose. Again, when filamentous, the ramifications differ much in thickness and in expansion, and in the extent of adhesion between the branches; where these are long and slender they are called 'capillary,' and where contiguous branches coalesce, they give rise to a submembranous condition. The degree and mode of division, the collection of the branches into bundles (*i. e.* fasciculi), or, on the contrary, their loose or diffuse arrangement, supply useful characters in the distinction of species. Again, the fronds differ in consistence, being in some genera or species more rigid, setaceous, or robust, in others softer, flaccid, and more delicate: these opposite conditions furnish Prof. Smith with grounds for the division of the genus *Schizonema* into two tribes.

The disposition of the frustules within the mucous investment supplies other important distinctions. Thus in *Dickieia* it is irregular; in *Mastogloia* each little frustule occupies "the summit of a little nipple-like cushion of gelatine;" in *Berkeleya* (XIV. 34, 35) the frustules are densely packed in the filaments; in *Encyonema* they occur mostly "in single file, except towards the extremities, where they are somewhat crowded" within the distinctly tubular filaments, and enjoy a certain latitude of movement; and, lastly, in *Colletonema* and *Schizonema* (X. 207, 208) they are arranged in one or more files according to the stage of growth, within less perfect tubes than in the genus last mentioned, and retained *in situ* by the mucus around.

Ehrenberg recognized this tribe of compound Diatomeæ, and introduced it as one of the sections of his great family *Bacillaria*, under the name of *Lacernata*, or *Naviculæ* with a double lorica. His acquaintance with the group was, however, very imperfect, and he appears to have comprehended in it organisms quite foreign to it, and to have failed to give that precision to his classification of the included beings which could alone confer a high scientific value and permanence upon it.

Of the Envelopes of the Frustules of Diatomeæ.—*The Silicious Shell or Lorica; its Divisions and Structural Composition, Markings, Striæ, Canaliculi, Puncta, &c.*—Sufficient has been said of the mucous coat which at certain times, and always in certain genera, surrounds the frustules of Diatomeæ. The frustules themselves remain to be described: they are hollow variously-shaped cells having but one cavity—unicellular, and a silicious outer wall, unaffected by a red heat and by strong acids, which would corrode and dissolve every other substance belonging to a living being except silex. This silex is stated not to polarize light, as does the mineral silex not in combination with organic beings; and the erroneous statement made by some authors, of the polarizing effect of some Diatomaceous shells is due to the circumstance, that they did not take care to thoroughly remove the organic carbonaceous matter with which the silex is in union in the frustules in question.

The silex, besides being united with organic matter, deposited it may be within a cellular tissue, is contaminated by iron, which Professor Frankland of Manchester states (*Smith, Synops.* p. xxi) "exists in the state of a silicate or protoxide .... "and he attributes to its presence" the brown colour which is assumed upon exposing the Diatoms to the influence of a moderate heat; the protoxide of iron, by the gradual absorption of oxygen, being converted into brown peroxide of iron, which assumes a redder tinge upon being more strongly heated."

The relative proportion of silica varies within considerable limits in different genera of Diatomeæ. In several genera, perhaps in marine ones exclusively, it is very deficient, and the wall of the frustule is little more than horny, or it may be even flaccid, as for example in *Dickieia* and *Schizonema*. The frustules of *Fragilaria*, *Striatella*, and *Podosira* are less firmly silicious than those of many others of the filamentous Diatomeæ. In some genera (those, viz., which produce tubular processes) silex is deficient or absent from the produced wall; in *Podosira* this deficiency occurs at the apex of the valves, and in Prof. Smith's opinion is probably intended "to allow a free secretion of the mucus which unites the frustules and provides a pedicle for their attachment to the plant on which they grow, as it does not occur on the non-attached valve of the first-formed frustule. In the living state the absence of silex is not perceived; but when the frustules have been macerated in acid, these portions of the valves appear as perforations, owing to the disappearance of the cell-membrane."

The frustules of the Diatomeæ are composed, as before stated, of two usually more or less convex valves, enclosing a single cavity, which becomes augmented by the growth of a third segment interposed between them, produced preparatory to the process of self-division. Meneghini asserts that the silicious shield or lorica is four-sided, and composed of four pieces or valves. Although this appears to be the true structure of some species, owing to the ready separation of the connecting membrane into two portions, yet the majority offer no countenance to the notion, the connecting membrane forming a continuous oval or circular ring. In *Triceratium*, however, is an example of an even more pseudo-multiple composition; for its prismatic triangular frustule breaks up into "two triangular plates or walls of silex forming the ends, and into three oblong rectangular pieces or bands forming the three sides, the latter usually dividing themselves into several elongated paralleliform pieces" (*Brightwell, J. M. S.* i. 248).

Again, in several genera, doubtfully arranged by Ehrenberg among the silicious Bacillaria, *e.g. Dictyocha* (XII. 62, 63) and *Mesocena* (XII. 71), the individuals are represented as composed of several segments united together. Each valve consists of a silicious lamina superposed on an organic soft lining (or primordial) membrane which immediately encloses the contents of the cell. Nägeli speaks of a mucilaginous pellicle on the inside of the organic layer as a sort of third tunic; and Kützing likewise discovers a thin stratum brought into view when recent frustules are dried, and particularly after heating them to redness, in the shape of an opake brownish stain, or of brown lines or points, extending not unfrequently over a considerable portion. To this supposed independent material its observer applied the name '*cement*,' imagining it to be the connecting matter of the valves and of frustules when in union, and attributed its brown colour to the presence of iron. This presumed layer of cement we can regard as nothing more than the stain produced by the oxidation of the salts of iron in chemical union with the silica, as Prof. Frankland has shown (p. 37). However, Meneghini adopts the notion of this third envelope or cement, inasmuch as he observes it to be constant, without employing the means used by Kützing to display it, not merely in the species enumerated by its discoverer, but in many others, and possibly in all (*R. S.* 1853, p. 361):—"For to me (continues the same author) it appears to correspond with that fine membrane of the *Achnanthidia*, which, according to Kützing's own observation, is always visible whenever the two new individuals (into which every Diatom is resolved in its multiplication by deduplication) begin to separate. The lines and points supposed to belong to the subjacent shield belong very frequently to this kind of covering." The analogy expressed in the quotation just given, between the delicate stratum—the 'cement' of Kützing, and the secretion poured out when self-division is proceeding, we cannot regard as correct; for this latter is a special and usually not persistent coating, in all probability exuded through the fissures or pores uncovered by the silicious lamina, by the subjacent organic membrane, and is withal destroyed by the heat generally required to bring the 'cement' into view, whereas the presumed coat is represented to be constant and also permanent both under the operation of fire and of acids. However, the belief in the existence of a vegetable membrane outside the silicious epiderm gains ground; for Mr. Shadbolt, in his presidential address before the Microscopical Society, 1858 (*T. M. S.* 1858, p. 72), states it as the result of his researches, that the frustule of *Arachnoidiscus* and of other forms consists of a *silicious framework*, over which is stretched a *species of membrane*, whether silicious or not he does not presume to decide, but certainly pliant to a considerable extent, capable of being partially rolled up by mechanical agency without breaking, and elastic enough to return to its original position when the extraneous force is removed. "The structure noticed by Mr. Roper in *Coscinodiscus labyrinthus*, and by myself in the more common species *C. radiatus* and *Triceratium favus*, I believe to be of precisely the same nature, and I am much mistaken if we do not find it in many other species of the Diatomacea."

In the accompanying part of the Journal (*J. M. S.* 1858, p. 162), Prof. Walker-Arnott refers with approval to this opinion of Mr. Shadbolt, and appends some most important remarks bearing on the presence or absence of this membrane in the determination of species. He observes that "There can be no doubt that these discs (*i. e.* of *Arachnoidiscus*) have a horny vegetable outer covering, in addition to the silicious one, and that by too long boiling in acid, as is necessary for guano, the marks are much obliterated or entirely removed. This, however, is not peculiar to the present genus, but may be observed, more or less, in all Diatoms, although sometimes the vegetable pellicle is very thin and may be removed by a few seconds' immersion in boiling nitric acid. It is this circumstance which gives a quite different appearance to the same species, according as the preparation is made. Thus, in *Actinocyclus* the vegetable epidermis is cellular, while the silicious part is striated like a *Pleurosigma*; and when the vegetable part is removed, we often find nodules or knobs along the margin (forming, then, the genus *Omphalopelta*), not previously visible. Those who describe Diatoms from slides are thus liable to commit great errors, and indeed no certainty can be obtained, except by getting the recent or growing Diatom and examining it, 1st, after being immersed for a short time in cold acid, or simply washed in boiling water; 2ndly, after being boiled in acid for about half a minute, or a whole minute at most; and 3rdly, after being boiled for a considerable time: we shall then see that many of the supposed distinct species of authors are the same, prepared in a different way. Of course, deposits or guanos can yield little or no information, although, when once a species has been determined by the way I have indicated, we may be able to refer forms occurring in guano or deposits to it with tolerable certainty."

Mr. Brightwell, speaking of the lorica or silicious epiderm of *Triceratium*, states that the valves are resolvable into "several distinct layers of silex, dividing like the thin divisions of talc, and frequently found of such exquisite delicacy as to be difficult of detection" (*J. M. S.* i. 248). The silicious lamina is generally looked upon as a production or secretion from the subjacent organic membrane, the true cell-wall. Nägeli (*R. S. Reports*, 1846, p. 220) says, "it lies outside the membrane, and must be regarded, from analogy with all other similar structures, as an extra-cellular substance excreted from the cell;" and, as Meneghini (*op. cit.* p. 360) adds, "in fact, an organic membrane ought to exist, for the silica could not become solid except by crystallizing or depositing itself on some pre-existing substance." Prof. Smith moreover states (*A. N. H.* 1851) that, apart from analogy, he has direct evidence of the independence of the silicious coat, having in his possession numerous specimens of a *Stauroneis* (probably *S. aspera*, Kütz.), in which the valves, after slight maceration of the frustules in acid, have, in part or wholly, become detached from the cell-membrane, leaving a scar on its walls bearing the distinct impression of the numerous and prominent valvular markings of this beautiful species. The same observer adds that he has in some cases noticed this organic membrane to contract around the cell-contents, upon the death of the cell. Again, the application of hydrofluoric acid, proposed by Prof. Bailey, to recent, and sometimes even to fossil shells, proves the same fact, by leaving a distinct internal flexible cell-membrane retaining the general form, after the dissolution of the silica by the acid. Further support, if needed, is furnished by the phenomena of cell-division, in which the lining membrane takes the initiative, and is followed by the doubling-in of the external coat upon it.

Nevertheless, although a silicious layer be artificially separable from the underlying organic coat, the relation and union of the two are indeed very intimate: and in the case of the apparently inorganic external lamina, the silex must be presumed to be deposited in some form of connective tissue, or, in other words, to permeate it. This opinion is advocated by Meneghini, who adduces in its support the circumstance of the silicious shield of *Achnanthidia* being covered with "a very delicate dilatable membrane, itself containing silica, as is proved by its sustaining unchanged the action of fire and acids." This author goes on to suggest that "this permeation may occur either in the wall of a simple cell, as is seen in the epidermal cells of many plants, or within minute cells, as in various plants and animals."

The surface of Diatomaceous frustules is generally very beautifully sculptured, and the markings assume the appearance of dots (puncta), stripes (striæ), ribs (costæ), pinnules (pinnæ); of furrows and fine lines; of longitudinal, transverse and radiating bands; of canals (canaliculi), and of cells or areolæ, whilst each and all these varieties present striking modifications in number, relative distribution, and in degree of development. Again, two or more sorts of markings may occur together in the same individual; and lastly, the entire frustule may be covered, or certain spots may be left unoccupied by them, in the form of bands, circular spaces, and the like.

The preceding account of the coverings of a Diatomaceous frustule make it clear that the apparent superficial markings, although chiefly due to the sculpturing of the silicious epiderm and to its internal involutions, are still in some instances and in a certain degree dependent on the overlying firm vegetable membrane which Mr. Shadbolt and others have shown to exist.

But, apart from this, modern research shows that puncta, lines, costæ and other markings are not the same in nature in all examples presenting them; that in one case a circular point is a depression, in another an elevation, and in a third a mere thickening or condensation of silicious material. So of lines or costæ: some are markings of the surface, and either furrows, ridges or thickenings, or actual canals, whilst others are the result of involutions or foldings of the internal coat or incomplete septa.

Again, the fine lines or striæ of many frustules are resolvable into rows of minute dots, as in *Navicula* and *Pleurosigma*. When the striæ are more distinctly composed of rows of dots or puncta, they are described as moniliform; examples occur in *Gomphonema* and *Podosphenia*.

Speaking of striæ, lines, and puncta generally, Prof. Smith (*op. cit.* i. p. xvii) confesses his belief that they are all "modifications in the arrangement of the silex of the valve, arising from the mode of development peculiar in each case to the membrane with which the silex is combined;" and, referring to the areolar or cellular-looking valves of *Triceratium* and of *Isthmia* especially, and to the recognized growth of organized beings by cells, he arrives at the conviction that "the valvular markings in every case arise from modifications of cellular tissue," which forms, so to speak, the matrix of the silicious epiderm. "No difficulty (he adds) presents itself to the supposition that the moniliform striæ of *Epithemia*, *Navicula*, and others, the circular markings of *Coscinodiscus eccentricus*, and the irregular star-like structure of *Eupodiscus Argus*, are all modifications of cellular tissue; and even in the costæ of *Pinnularia*, and the unresolvable striæ of *Eupodiscus sculptus* and others, it is not difficult to conceive we have confluent cells whose union gives rise to the appearance of lines or bands."

Great difference has existed, and even yet exists, in the interpretation of the exact nature of many superficial markings. Some circular dots or puncta are held by certain observers to be pits, by others holes, and by others to be elevations. So of stripes, costæ, and pinnules: to some, such markings in special instances are ridges; to others, furrows or fissures; to others, elevations; and to others again, canals. The ardent microscopical research of this period is daily diminishing the number of these enigmas, and introducing certainty in place of doubt and vague conjecture. To Ehrenberg's apprehension, many puncta were real pores, and many striæ or costæ real fissures; the former of these were supposed to give exit to a few or to multitudinous imaginary 'pedal organs' for locomotion, the latter to serve for the passage of ova, and generally to bring the presumed internal animal organization into immediate relation with the external medium around it.

Perhaps the discussion respecting the nature of apparent pores has been most animated in the case of the genera *Navicula* and *Pinnularia*, which present a large rounded spot at each extremity of the frustule and a central space known as the umbilicus, with a tubular or canal-like band connecting them together (XII. 15, 21, 46; XVI. 1). From the umbilicus, Ehrenberg believed a single locomotive organ to proceed—an undivided sole-like foot, similar to the locomotive organ of snails, whilst he represented the terminal points to be orifices for the purposes of nutrition (IX. 134). Although denying the offices assigned them by the Berlin micrographer, Kützing coincided with him in the belief of their being actual pores, and supposed that they give exit to a gelatinous substance, such as is actually found surrounding some *Naviculæ*, and becomes a prominent character in the tribe of Diatomeæ represented by *Schizonema*. Schleiden (*Principles of Botany, by Lankester*, p. 594) speaks of the longitudinal band as a cleft, and of the median and terminal spots as circular enlargements or thickened spots of silicious matter. He moreover appends an enlarged lateral view of a *Pinnularia* (XVI. 2, 3, 4, 5), to prove that the seeming central orifice is simply a depression. This explanation of their nature coincides in the main with that given by Prof. Smith, who asserts that these markings are due to a longitudinal band of condensed and more solid silex, widened into small expansions at the centre and extremities, or at the extremities only, and probably designed to give firmness to the valve. "That these expansions (he adds) are not perforations in the valve, as alleged by Ehrenberg, and acquiesced in by Kützing, might be shown in various ways. The internal contents of the frustule never escape at such points when the frustule is subjected to pressure, but invariably at the suture or the extremities .... nor does the valve when fractured show any disposition to break at the expansions of the central line, as would necessarily be the case were such points perforations, and not nodules. Moreover, the central band of silex is itself frequently traversed by a narrow line which arises from the confluence of a series of cells, which thus form a minute tube; but this tube invariably ends in a rounded extremity at the central and terminal nodules, and does not pass into an opening or aperture in the valve ...... The bending down of this tube and the thickening downwards of the silex at the nodules give the semblance of depressions to the surface of the valve at such places. But I am disposed to think that this is merely an optical appearance, and at all events assured that no perforation exists at such points, and that the terms applied to these nodules by different authors, implying that they are openings or ostiola, are altogether inadmissible."

Examples of nodules at the centre and extremities are found in the genera *Amphiprora*, *Pinnularia*, *Navicula* (XII. 5, 6), and *Gomphonema* (XII. 15, 21, 46). In *Stauroneis* the central nodule is developed transversely, so as to form a smooth transverse band or "stauros" free from markings (XII. 7, 8, 18). A median longitudinal ridge or band exists in *Navicula*, *Stauroneis*, &c., whilst in *Amphipleura* (XIII. 1, 2) two ridges are noticeable, but whether these are of the same nature structurally is uncertain. In *Doryphora*, again, there is a median band, but no nodules distinguishable; and in *Eunotia* and *Himantidium* the terminal nodules would seem exceptional in character, being due, as Prof. Smith supposes, "to an inflection of the valves at the point of junction." The rounded space in the centre of the discoid valves of *Actinocyclus* (XI. 132) and *Arachnoidiscus* (XV. 18-21), which is devoid of areola, is designated by him a pseudo-nodule, in order, we presume, to contrast a mere bare space with the like smooth but condensed and thickened spots described as nodules.

In this record of opinions, those of Siebold and Nägeli (*J. M. S.* i. 196) should not be omitted:—"Precisely at the spots (says the former writer) at which Ehrenberg and others suppose they have seen six openings (*i. e.* three on each valve) in *Navicula*, the silicious cell-membrane is thickened, and consequently forms so many rounded eminences which project internally." These views thus far tally with those of Prof. Smith and others; however, a few lines further on in his essay, Siebold expresses the belief that the lines running along the middle of the surfaces from one thickening to another "are to be referred to a suture, fissure, or rather gap, in which no silicious matter is deposited, so that in these places the delicate primordial membrane which lines the silicious shield can be brought into close relation with the external world. I come to this conclusion from the circumstance that it is exactly at these four sutures or fissures that the water surrounding the *Navicula* is set in motion." (See p. 50.)

Upon the whole question of the actual nature of the markings on the surface of the silicious frustules, we are happy to add a paper published by Prof. Bailey (*Sill. Journ.* ii. 349), which appears to afford a satisfactory elucidation. We present it entire, with the practical notes on manipulation, so that our readers may undertake a critical examination for themselves:—

"I now offer proof which removes all doubt, and shows that these markings are neither apertures nor depressions, but are in reality the thickest parts of the shell. If the shells are placed in dilute hydrofluoric acid and watched by the aid of the microscope as they gradually dissolve, the thinnest parts of course dissolve first, and apertures, if any exist, should become enlarged. Now the very parts which have been called orifices by some, and depressions by others, are the last of all to disappear as the shell is dissolved. This mode of observation, besides establishing the fact that these are the thickest parts of the shell, reveal many interesting particulars of structure. Thus, in the large *Pinnularia*, it may be seen, with even a low power, that the two parallel bands (separated by a canal) which reach from the central knob to the terminal ones, and which appear smooth before the application of acid, become distinctly striated after their surface is dissolved off, as does also the central spot itself, showing that striæ which existed in the young shell are covered up and nearly obliterated by subsequent deposits. In *Staurosira* the cross-band and the two longitudinal bands are the last to dissolve, and these last bands, as in most Diatomacea, appear separated by what is either a canal or thin portions of the shell. In *Grammatophora* the undulating lines are internal plates, which are the last to dissolve. In *Heliopelta, Actinoptychus*, &c., the polygonal central spot is the last to disappear. In *Isthmia*, the spots on the surface, which at first appear like granular projections, are in reality thin portions of the shell, and under the action of the acid they soon become holes. The acid also proves that the larger spots at the transverse bands are a series of large arcuate holes in the silicious shell, and the piers of this series of arches remain some time after the rest of the shell has vanished.

A few directions on the mode of manipulation may be useful. As the fumes of the hydrofluoric acid, if they reach the lenses, would greatly injure them, it is advisable to protect the front face of the objectives by temporarily connecting to them a thin plate of mica by Canada balsam, as mica resists the action of hydrofluoric acid much better than glass. I prepare the cell in which the solution is to take place by cementing a plate of mica to a glass slide, and then cover all its surface, except a central small disc, with wax. On this disc, which forms a cell, the shells are put with a dish of water, and after adding a drop or two of acid by means of a dropping-rod of silver or platinum, the cell is covered with another plate of mica, and the slide is then placed under the microscope."

Some markings of the surface, apparent only as striæ under inferior magnifying powers, are in several genera resolvable, as before noticed (p. 40), into rows of rounded dots, *e. g.* in *Pleurosigma*; and in consequence such specimens have been employed to try the relative powers of microscopes, and are spoken of as 'test objects.' But the powers of microscopes have been more severely tested of late years, by the endeavour to ascertain whether such dots are elevations or depressions of the surface, and, as might be expected, the dissension on this matter has equalled that respecting the central band and umbilicus.

Dr. J. W. Griffith is in favour of their being depressions (*Proc. Roy. Soc.* 1855). He argues that, as the markings "are evidently depressions in the genera and species with coarsely marked valves (*Isthmia*, &c.), we should expect from analogy that the same would apply to those with finer markings (those viz. in dispute, *Gyrosigma, Pleurosigma*, and others). And this view receives further support from the fact that under varied methods of illumination corresponding appearances are presented by the markings when viewed by the microscope—from those which are very large, as in *Isthmia*, through those of moderate and small size, as in the species of *Coscinodiscus*, down to those in which they are extremely minute, for instance in *Gyrosigma*, &c. The angular (triangular or quadrangular) appearance assumed by the markings arises from the light transmitted through the valves being unequally oblique; this may be readily shown in the more coarsely marked valves (*Isthmia, Coscinodiscus*), which present the true structural appearance when the light is reflected by the mirror in its ordinary position, and the spurious angular appearance when the light is rendered oblique by moving the mirror to one side." Another statement is put forward by the same author in the *Micrographic Dictionary* (Introduction, p. xxxiii) in support of his opinion, viz. "that the line of fracture of the broken valves passes through the rows of dots on the dark lines corresponding to them, showing that they are thinner and weaker than the rest of the substance. Had these dots represented elevations, the valves would have been stronger at these points."

The more prevalent opinion, however, is, that these delicate dots in rows are elevations of the surface. Mr. G. Hunt (*J. M. S.* 1855, pp. 174–175) adduces an observation to demonstrate this fact. He found that on a specimen of *Pleurosigma* being moistened, the markings were almost entirely obscured, but that on the application of a gentle heat "the moisture slowly retreated, leaving patches of the shell dry, and with the markings as distinct as before." On observing these dry parts of the shell, they were seen to be uniformly bounded by *straight* lines, *parallel* to the two directions of least distance of the dots. "Now (continues Mr. Hunt), on the supposition of these little dots being elevations, the phenomenon appears to me easily explicable on the principle of capillary attraction. We can readily conceive the moisture clinging from one dot to another; and it would always have a tendency to arrange itself in lines parallel to the directions of least distance.

I am, however, quite at a loss to imagine how the same principle would apply on the hypothesis that the dots are depressions, nor do I see upon what principle the phenomenon is explicable."

A direct demonstration that the markings in general of the Diatomeæ are elevations is attempted by Mr. Wenham, whose knowledge of optics and practical skill in mechanical manipulation are not exceeded by any microscopist of the present day (*J. M. S.* 1855, pp. 244–245). To quote his words—"A careful study of the coarser varieties will distinctly prove that the markings are raised ribs or prominences on the surfaces, in some instances on one side of the shell only, as seen in the *Campylodiscus spiralis* and others. Though the microscope proves this fact satisfactorily in the large species, it fails to do so in the most difficult specimens, chiefly on account of the above-named deceptive appearances, arising from the irregular refraction and reflection of light. It occurred to me that it might be possible to obtain a perfect cast or impression of the structure; and by viewing this as an opake object, the error, if arising from refraction, would be avoided, and a discovery might be the reward of the experiment. I have succeeded in effecting this by means of the electrotype process, which for many reasons is to be preferred, as it does not distort the object, and is so minutely faithful that even the mere trace of organic matter, left by a slight finger-mark, is perfectly copied. The method I have adopted is this:—Procure a small plate of metal highly polished (a piece of daguerreotype plate answers extremely well), and, after gently heating it, rub a piece of bees-wax over the surface; while this is still melted wipe it nearly all off again with a piece of rag, so as to allow a very thin film to remain; when the plate is cold, arrange the Diatomacea or other objects, previously moistened, upon the waxed surface, heat the plate again to at least 212°, in order to cement the objects on it. The wax serves a twofold purpose: first, its interposition prevents the possibility of a chemical union of the metallic deposit with the plate; and secondly, the object is securely held thereto by its agency. The objects are now ready to receive a coating of copper. If the battery is in good working order, three or four hours will give a film sufficiently strong to bear removal; when this is stripped off, if the process has been properly managed, the objects will be seen imbedded in its surface; whether they are silicious or organic, they may be entirely dissolved out by boiling the cast in a test tube with a strong solution of caustic potash, and afterwards washing with distilled water; the copper film may then be mounted in Canada balsam. By these means I have obtained distinct impressions of the markings of some of the more difficult Diatomacea, such as *N.* (*Pleurosigma*) *Balticum*, *P. Hippocampus*, &c., leaving no doubt of their prominent nature." (See *Microscopic Cabinet*, ed. 1832, chap. xvi. and xviii.)

Besides the superficial markings explicable on the supposition of an investing areolar membrane, and the sculpturing of the silicious epiderm, there are others, dependent on structural modifications of the silicious laminæ of the valves, and on inflections of these internally. Among the former are many of the stronger-marked costæ and pinnules of Ehrenberg; and among the latter are to be reckoned the imperfect partitions ('septa') seen in several genera, and those peculiar processes of the internal surface which Kützing called '*vittæ*.' Schleiden described 'pinnules' to be clefts or fissures. "In these spots (says he), the shield consists of two leaves lying one over the other; these leaves are penetrated by the small clefts, which, when both the lamellæ touch each other, are somewhat broader, which explains the varying breadth of the clefts according to the alteration of the foci. Fragments in which this structure is clearly represented may be frequently obtained by crushing the shield." (XVI. 5, 6.)

Prof. Smith likewise describes inter-lamellar channels; under the name of '*canaliculi*,' "hollowed out between the silicious epiderm and internal cell-membrane, and apparently formed by waved flexures of the epidermal envelope......They are very conspicuous in *Epithemia longicornis*, and form distinctive characters in the genera *Surirella* and *Campylodiscus*." This observer also regards them "as minute canals which convey the nutrimental fluid to the surface of the internal membrane," this fluid entering them from without through pores or fissures existing along the line of suture of the valves (p. 50). That these canals are not modifications of the cellular structure of the silicious epiderm is shown by the circumstance of the striæ passing uninterruptedly over the entire surface of the valves in some *Epithemiæ*.

The costæ of *Campylodiscus* equally appear to be canaliculi, and are disposed in a radiate manner. In *Surirella* and *Tryblionella* these canals are usually parallel, whilst in *Mastogloia* they take the form of loculi.

Kützing assigned a special structure and purpose to the markings he called '*vittæ*,' and used them in forming a subsection of Diatomeæ he called *Vittatæ*. The Rev. Prof. Smith remarks that to him these markings do not seem special organs, but modifications in the outline of the valve, which is inflected. In *Grammatophora* (XI. 48, 49, 52, 53) these inflections constitute a leading feature of the genus, and, from their resemblance to written characters, have suggested its name. In this instance they form incomplete septa.

The terms striæ and costæ or pinnules are not synonymous. Striæ are the finer lines of slight breadth, which may look like narrow grooves or ridges, whilst costæ or pinnules are the wider markings, having an evident double contour, and the appearance of fissures or canals. The fineness of some striæ is such that, as before noted, they may be readily overlooked; however, their presence, when not positively demonstrable, may be assumed by the colours displayed on focusing dried specimens. An analogous fact presents itself in the case of mother-of-pearl, which owes its varying and beautiful colours to the existence of fine lines covering its surface. The colour varies in different species, and is due to the refraction of the rays of light passing through the silicious epiderm; its shades depend on the direction of the striæ and on their distance from each other; its aid may therefore be advantageously evoked in the determination of species.

Striæ generally seem to be produced by the confluence of minute rounded points or beads—in other words, are commonly moniliform, and often extend, as products of an investing areolar tissue, over the entire surface of the valves, unlike those costæ which originate in structural peculiarities of the silicious plates. Rows of puncta occur in *Nitzschia*, and moniliform striæ in *Navicula*, *Pleurosigma*, *Gomphonema*, and *Podosphenia*. To the confluence of the superficial cells, Mr. Smith attributes the production of the costæ of *Pinnularia*, whilst those of *Achnanthes* he looks upon as thickenings on the under surface of the silicious valves, and generally similar to those of *Isthmia*, which line the valves and anastomose on their under surface; lastly, the striæ of *Rhabdonema* are constituted of series of oblong cells.

The value of the external markings of Diatomeæ, in a systematic point of view, has been much discussed. Ehrenberg assumed the number of striæ or of costæ or pinnules to be constant in the same space in each species, and accordingly gives the number of striæ counted within a given fraction of a line. A great multitude of species was the consequence of this plan; nevertheless the mere fact of number of striæ within a given space cannot be esteemed a valid specific character by itself; for it seems quite clear that the relative closeness of striæ, their number within the ·001 of an inch, varies according to the age and to the size of the valves, and both size and figure are considerably affected by circumstances of growth, of locality, and the like. A writer in the *Microscopical Journal* (1855, p. 307) suggests that the number of striæ on the entire valve may supply a more stable character; yet even on this point we are wanting in direct observation to show that this number may not be affected by accidental circumstances.

Although "the relative distance of the striæ and their greater or less distinctness" be accounted by Prof. Smith of specific importance, yet he is obliged to admit (*J. M. S.* 1853, p. 133) that it is by no means certain that these features may not to a slight extent be modified by localities and age, and is disposed to believe that they are certain guides only when we have made allowance for these conditions, and that while they are constant in frustules originally from the same embryo, they may slightly vary in those which owe their birth to different embryonic cells. It is also worthy of note that, in certain instances, *e. g.* in *Odontidium hyemalis*, *Epithemia Arcus*, &c., the costæ are frequently more numerous on one valve than on the other.

Other illustrations of the variation in the number and in the distinctness of striæ in the same species are to be found in the late lamented Dr. Gregory's valuable papers (*T. M. S.* 1855, p. 10). The relative position of striæ—if parallel or radiate, their moniliform or confluent character, their equal and general diffusion over the entire surface, or their absence at parts, are other circumstances available for the purposes of classification.

Besides striation, the other descriptions of superficial markings are resorted to for specific and generic characters. Such are the presence or absence of a median band, with central and terminal nodules, the existence of a transverse band, the figure, relative position and aggregation of the areolæ or cells of the surface. The median and transverse bands have been employed by all systematists, and would seem well suited to furnish characteristics by their constancy. The same may be said of the pore-like spots or nodules. Kützing went so far as to make the presence or absence of a central nodule or umbilicus the turning-point in his grand division of the Diatomeæ into umbilicated and non-umbilicated.

Lastly, speaking generally, the precaution intimated by Prof. Walker-Arnott (p.39), of having specimens, intended to be compared together for the determination of specific forms, similarly prepared, must ever be borne in mind where the superficial markings are referred to for characters; otherwise an excessive and erroneous multiplication of species, and a deplorable confusion will result.

We have already seen that the connecting membrane is not an essential segment of a Diatomaceous frustule, but an after-development in connexion with the process of self-division; yet, notwithstanding, it is so frequently present, and in many examples, its dimensions, and characters are so marked, that it supplies an important element in specific and generic descriptions.

In the circular and discoid Diatomeæ, it assumes the form of a continuous ring (XI. 40, 42), but in many oblong and navicular frustules it is itself oblong or navicular, having a figure the reverse of the valves it is placed between (XII. 17, 24, 31; XIII. 5, 6, 7). In these latter and in other instances it is frequently separable into two portions, at the opposite extremities of the frustules where the silex is absent; and hence it is that the shells of the Diatomeæ have been described by Meneghini and other writers as composed of four segments.

In general, the proportion of silex in its constitution is less than that in the valves; and the existence of markings—of areolæ, striæ, and the like—is also much rarer. Where they do occur, they furnish useful particulars in defining species and genera. The small development of the connecting membrane in *Pleurosigma* is a remarkable feature of that genus, whilst in *Gomphonema* (XII. 28, 53), and other genera with cuneate (wedge-shaped) frustules, the figure is due to the greater development of this segment at one end than at the other. In *Amphiprora* (XIII. 5, 6), *Achnanthes*, *Himantidium* (XII. 50, 52), and *Melosira*, the connecting membrane is striated, and in *Biddulphia* (II. 48), *Isthmia* (X. 183), and *Amphitetras* (XI. 21, 22) is cellulate or areolate.

In certain genera the connecting membrane takes on an extraordinary development, which greatly modifies the figure of the frustules. Instead of being limited to the interspace between the opposed valves, it extends on either side beyond the sutures (XII. 9), presents itself as a band of greater or less width, and acquires an unusual persistence. Under this form it constitutes the '*cingulum*' of descriptive writers, and is seen in *Amphitetras*, *Biddulphia*, *Podosira*, and *Melosira*. In the last two genera, Prof. Smith tells us, the persistence of this circular band is "eminently conspicuous, retaining the frustules after self-division in a geminate union until the self-dividing process is renewed."

CONTENTS OF FRUSTULES.—*Nucleus, supposed Digestive Sacs, Reproductive Vesicles, &c.*—The organic membrane of the frustules of Diatomeæ, strengthened externally by the silicious plates, encloses within its cell-like cavity a soft mucilaginous substance filled with numerous granules and globules, and usually of a yellow-brown or orange-brown colour, but at times of a green hue, and technically known as the '*endochrome*,' or in Kützing's phraseology, the '*gonimic substance*.' The granular matter is particularly aggregated about the organic wall, leaving the central portion more clear. In this clear central space is a transparent vesicle, representing the nucleus of the cell, having the granules frequently collected around it in an annular form. Nägeli states that the nucleus, enclosing a nucleolus, lies sometimes free in the centre of the frustular cavity, but at other times is affixed at one spot to the wall, and therefore 'parietal.' He also describes two sorts of nuclei, viz. primary and secondary, attributing to the former the active part. Schleiden represents the nucleus to be primarily concerned in the original formation of the cell, as well as in its subsequent multiplication by self-division.

Among other elements of the endochrome are more or fewer rather translucent globules, which Prof. Smith believes, like Kützing, to be secretions of the cell, of a fatty or oily composition, and to be the source of the peculiar odour emitted on burning the Diatomeæ. In support of this view Kützing states that he has occasionally seen two coalesce, proving the absence of proper walls, and expresses his conviction that these corpuscles are akin to the amylaceous secretions of the Desmidieæ and Confervæ and the starch-granules of the higher vegetables.

These globules are smaller than the nuclear space, and occupy a pretty constant and definite position. "The number of these globules is frequently four, often placed near the extremities, or more rarely clustered round the central vesicle." Meneghini (*op. cit. R. S.* p. 364), alluding to these vesicles, states them to vary in number, size, and disposition at different stages, and according to various conditions, even under the eye of the observer.

These apparent oil-globules were called by Ehrenberg male sexual glands or testes, whilst those other vesicles distributed within the mucilaginous matter, often about the nucleus, were named stomachs. The latter idea he based especially on a series of experiments to introduce colouring matter into the interior of the frustules, in which he believed he succeeded. The species mentioned are *Navicula gracilis*, *N. Amphisbœna*, *N. viridula*, *N. fulva*, *N. Nitzschii*, *N. lanceolata*, and *N. capitata*; also *Gomphonema truncatum*, *Cocconema cistula*, *Arthrodesmus quadricaudatus*, and *Closterium acerosum*. The two last, however, are Desmidieæ. In the seven species of *Navicula* enumerated, from 4 to 20 little stomach-sacs are said to have become filled with the indigo employed as the colouring matter.

"This effect (as Meneghini remarks) could only be produced by keeping the Diatomeæ a long time in water laden with particles of indigo, and often renewed." Kützing deduced an opposite conclusion from these experiments, viz. that they were solid corpuscles which, being seated near an opening, exerted an especial attraction upon the colouring matter. Meyen argued, so long since as 1839 (*Jahresbericht d. Akad. Berlin*), against the supposed stomach-sacs and the entrance of colouring matter within them. His objections are thus expressed:—"On the one hand, I can see no stomach-sacs in the *Naviculæ*, and never observed in the living and moving *Bacillaria* the colouring matter received at one extremity and carried towards the centre, where these stomach-sacs should lie, whilst among the ciliated Infusoria such observations are easy; on the other hand, it is not uncommon, especially in the larger species, to see the molecules of the colouring matter employed, lie upon the middle of the broad ventral surface, looking as if actually within the organism; but if a glass plate be placed upon the specimen and then carefully removed, the particles of colouring matter are taken away with it." Even Ehrenberg admitted that the presumed stomach-sacs varied in number, were quite irregular in their disposition in the interior, and not unfrequently wanting altogether. This last circumstance, Kützing remarks, is opposed to the belief in their digestive functions, since such important organs as stomachs can never be supposed absent.

Although the existence of this fanciful polygastric apparatus in the Diatomeæ is scarcely worth controverting, yet we may add to the above objections to it the fact that, in the hands of other experimenters, the attempt to introduce colouring matter by any definite apertures into the frustules of this family has been unsuccessful.

The arrangement of the mucilaginous endochrome, or rather of its prominent globules, vesicles, and granules, is sufficiently definite and constant in the same species to afford useful characteristics. At one time these molecules are diffused rather irregularly; at another they are collected in a rounded heap towards the centre, whilst at another they are disposed in lines radiating from the nucleus, or formed in a layer upon the cell-wall,—"at all times" (adds Prof. Smith) "having one or several oily globules, which occupy in different species different positions, but are constant in number and position in the same species. The minute granules" (he continues, i. p. 20) "are generally accumulated in thin layers towards the internal cell-walls: when the frustule is so turned that this layer of endochrome is presented edgeways to the eye, the granules appear to be chiefly aggregated into two plates applied to the opposite sides of the frustule; and when self-division is in progress and the cell-contents are divided into two portions, such a separation or temporary aggregation must necessarily ensue; but in the simplest condition of the frustule the contents are diffused over the entire surface of the cell-walls, precisely as may be seen in the cells of many of the larger Algæ, or of some water-plants of a higher order, as in the leaves of *Hydrocharis Morsus-ranæ* and others."

Schultze has recently represented (*Müll. Archiv*, 1858) a definite peculiar disposition of the endochrome—of its mucilaginous and granular portions and its coloured corpuscles. In the more or less quadrate frustules of *Denticella*, and in the circular ones of *Coscinodiscus*, he describes the existence of a central clear vesicle, from which thin, finely granular lines or threads extend and intersect and branch in a reticulate manner, with a more or less distinct radiation, the more fluid contents flowing between them. In the long cylindrical frustules of *Rhizosolenia*, on the contrary, these granular mucilaginous threads run longitudinally. Within these threads the colouring, yellowish-brown corpuscles, not circular, but, as Schultze says, irregularly multangular, are disposed and retained in their position. Although these researches extend to so few forms, yet we are disposed to believe that this disposition of the elements of the endochrome will be found to be the rule. A regular arrangement is figured in many drawings of the Diatomeæ by various observers; and where it does not appear it is most probably due to the want of attention to its presence,—or to the excessive multiplication of the colouring corpuscles, causing them to appear spread beneath the envelopes as a pretty uniform layer. A definite disposition of the chlorophyll-granules is common in plants, particularly among the lower Algæ, and owes its constancy to the presence of the mucous and less fluid contents, which are condensed from the surrounding fluid in the form of filmy threads, and serve as a nidus to the colouring particles. In this disposition, therefore, of the endochrome and its corpuscles we perceive a vegetable character, as contrasted with what is seen in animal cells, and find in it an additional argument for the vegetable nature of the Diatomeæ.

Notwithstanding that the endochrome is, by pretty general consent, homologous with that of recognized vegetable Algæ, still it would seem to be of a different chemical composition as well as of another colour. Kützing, indeed, insisted on the fact of the similarity of the endochrome to the gonimic substance of Algæ, from the circumstance that, by means of alcohol, he was able to extract a colouring matter similar to chlorophyll; yet Rabenhorst and others have remarked a difference in chemical nature. Prof. Smith again, whilst admitting the imperfection of our knowledge on this point, goes on to say that "the tincture of iodine causes the internal membrane to contract upon the cell-contents, and converts these from the golden yellow which they exhibit in some species, into bright green, and that a weak solution of sulphuric acid, while it effects the same contraction in the cell-wall, gives to the contents, which have been previously treated with iodine, a dark-brown hue: alcohol, on the other hand, as in the case of vegetable cells in general, dissolves the utricle and its contained endochrome, or at all events entirely removes their colour, and leaves their silicious epiderm in a state of perfect transparency. It does not, however, dissolve the envelope in which the frustules of the frondose forms are imbedded, nor the filamentous stipes or gelatinous cushions to which other species are attached."

Meneghini (*op. cit. R. S.* p. 365) contends that the identity in nature of the endochrome of Diatomeæ and of Algæ is not proved. "Its colour is different; and it is differently coloured by chemical reagents. The resemblance to it in some instances, as in *Melosira*, in regard to conformation and successive alterations, is only in appearance. In the endochrome of Algæ the monogonimic substance begins by presenting a granular appearance; then it becomes distinctly granulated and changes into the polygonimic substance, so minutely described by Kützing. But these changes do not occur in the coloured substance of Diatomeæ. If we insist on a parallel, we can only compare it to the cryptogonimic substance of *Byssoidia*, *Callithamnia*, *Griffithsia*, and *Polysiphonia*. It divides into two parts which successively undergo ulterior division; and in regard to these changes we may observe that there is an essential distinction between those that occur during life and those that take place after death, the greater number happening in the latter condition. . . . . The identity of this substance with endochrome is contradicted by Kützing's own experiments, ... which prove it to be very rich in nitrogen: it emits ammonia copiously when decomposed by heat; and this can only proceed from a substance abounding with it, which such a decomposition compels it to yield up. Nor, on the contrary, do I believe that there is any weight in the argument from the solubility of its colouring principle in alcohol; for this is not aproperty peculiar to chlorophyll, or to any substance of vegetable origin."

The contents of the frustules are brought into relation with the surrounding medium through certain pores or fissures, which have been referred to as existing here and there along the sutures between the opposed valves, or otherwise between the valves and the interposed connecting membrane. The existence of such openings in the silicious envelope, and the consequent exposure of the organic internal or primordial membrane in the situations mentioned, have been demonstrated chiefly by the researches of Prof. Smith, who applies to them the name of '*foramina.*' They are thus described (*op. cit.* i. p. 15):—"Along the line of suture in disciform or circular frustules, but more generally at the extremities of the valves only, when the Diatom is of an oblong, linear, or elongated form, there exist perforations in the silex which permit the surrounding water to have access to the surface of the internal cell-membrane. The formation of silex seems occasionally to be arrested in the neighbourhood of these spots; and the connecting membrane is in consequence either wholly or partially interrupted at such places. Thus, after the internal cell-membrane has been removed by acid, when it often happens that the valves fall away from the connecting membrane, the latter separates into two parts; and the frustule has in consequence been described as consisting of four plates. The interruptions in the silicious epiderm are usually apparent as slight depressions at the extremities of the frustule; and the appearances they present have been denominated 'puncta' by Mr. Ralfs. In some species these interruptions are more numerous, being found along the entire line of suture, and are often connected with minute canals hollowed out between the silicious epiderm and the internal cell-membrane, and apparently formed by waved flexures of the epidermal envelope." The latter constitute the canaliculi heretofore spoken of (p. 45).

Siebold regarded the longitudinal bands having a double outline, and extending from the apparent dots or pores at either end of *Naviculæ* to near the centre, to be fissures; but the account previously given proves this able man to have been mistaken on this point. Like Prof. Smith, however, he concluded that the internal membrane was imperforate, and that it served as the medium for the exosmosis and endosmosis attending the function of nutrition.

Movements of the Diatomeæ;—their character and causes;—Cilia;—Circulation of Contents;—Respiration.—The peculiar movements noticed in many Diatomeæ have attracted the observation of all microscopists, and have induced many, especially among the older observers, to receive it as evidence of their animal nature; but even those who agree on this point are in no better accord among themselves respecting its cause than are those who refer these beings to the vegetable kingdom.

The power of movement is not confined to those only which are free, but also to concatenate and to some fixed forms, *e. g. Synedra*, which move on their fixed extremity. There is considerable diversity both in the manner and extent of movement of different species; but in none is it exhibited in an equal degree to that seen in the spores of Algæ. "The motion," says Prof. Smith, "is of a peculiar kind, being generally a series of jerks producing a rectilinear movement in one direction, and a return upon nearly the same path, after a few moments' pause, by another series of isochronal impulsions. The movement is evidently of a mechanical nature, produced by the operation of a force not depending upon the volition of the living organisms: an obstacle in the path is not avoided, but pushed aside; or, if it be sufficient to avert the onward course of the frustule, the latter is detained for a time equal to that which it would have occupied in its forward progression, and then retires from the impediment as if it had accomplished its full course. There is certainly no character of animality in the movement; and the observer, familiar with the phenomena of life in the earlier stages of vegetable existence, is constrained to see a counterpart in the involuntary motions of the filaments of the Oscillatoriecæ, or of the gemmiparous spores of the Fuci and Confervæ."

This same view was taken by Morren in 1839 (*op. cit.*), who says—"The movement of the Bacillaria, however free it may be, is by no means so free and active as that of the spores of Algæ, which are plants, or, at least, parts of plants; and the motion is no positive ground for the belief in their animality."

The cause of the motion of the Diatomeæ has hitherto not been satisfactorily determined. To the hypothesis of a snail-like expanding foot projecting from the central pore or umbilicus, advanced by Ehrenberg, we have already alluded (p. 41); and since no one original observer, in spite of the best-directed efforts, has been able to detect the remotest evidence of such an organ, and as all evidence goes to show that no actual perforations exist at the point indicated for its extrusion, it would be useless to raise any argument upon it. This distinguished naturalist subsequently satisfied himself of the presence of other locomotive organs in a *Navicula* (*Surirella gemma*, XII. 3, 4), which he has thus described:—"Instead of a snail-like expanding foot, long delicate threads projected, where the ribs or transverse markings of the shell joined the ribless lateral portions, and which the creature voluntarily drew in or extended. An animalcule $\frac{1}{18}$th of a line long had 24 for every two plates, or ninety-six in all; and anteriorly, at its broad frontal portion, four were visible. Whether these organs were supernumerary, and existed along with cirrhi, &c., and with the flat snail-like foot which the rest of the *Naviculæ* possess, could not be determined. Longitudinal clefts at the broad side of the shell were not present; but as many as 96 lateral openings for the exit of the cirrhi were perfectly distinct." These ciliary processes were further stated to be actively vibratile, and to be retracted or extended at short periods.

Prof. Smith has remarked on this appearance, that the presence of hairs apparently on all parts of the frustule may often be detected, and that he has noticed them on nearly every occasion on which he has gathered this species, but in no case has he been able to perceive any motion in such hairs; and he therefore concludes that they are merely a parasitic growth, such as the mycelium of some Algæ. He has also seen similar appendages to other Diatomeæ, but in every case devoid of motion.

The notion of exsertile and retractile feet has been renewed by M. Focke (*Comptes Rendus*, 1855, p. 167), who attributes the movements of *Navicula* to such organs of a temporary kind, which he says pass through openings he has detected on the sides of the lorica.

Nägeli offered the following, and, to Siebold's mind, satisfactory, explanation of the forward and backward movement, as well of many Desmidieæ as of Diatomeæ (*J. M. S.* 1853, p. 195). "The cells," he writes, "have no special organs for these movements. But as in consequence of their nutritive processes they both take in and give out fluid matters, the cells necessarily move when the attraction and the emission of the fluids is unequally distributed on parts of the surface, and is so active as to overcome the resistance of the water. This motion, consequently, is observed more particularly in those cells which, in consequence of their taper form, easily pass through the water; these cells, moreover, move only in the direction of their long axis. If one half of a spindle-shaped or ellipsoidal cell chiefly or entirely admits material, the other half, on the contrary, giving it out, the cell moves towards the side where the admission takes place. But as in these cells both halves are physiologically and morphologically exactly alike, so it is that it is first the one and then the other half which admits or emits, and consequently the cell moves sometimes in one, at other times in the opposite direction."

In our apprehension, this mechanical interpretation of the phenomenon is not sufficient; the alternate reception and discharge of fluid matters by each opposite half requires an effort of imagination, to conceive, unwarranted by analogy. We shall, however, presently see that Prof. Smith gives the preference to this supposition, amid the many conflicting fancies of authors and the obscurity of the question.

Encouraged by apparent success in discovering cilia on the fronds of Desmidieæ, Mr. Jabez Hogg searched for them on Diatomeæ, and tells us (*J. M. S.* 1855, p. 235) that he has repeatedly satisfied himself that their motive power is derived from cilia arranged around openings at either end,—in some also around the central openings, which, with those cilia at the ends, act as paddles or propellers. He, moreover, states his impression that the frustules have a degree of volition sufficient "to move along and to steer their course; for intervals of rest and motion are most clearly to be distinguished." To this belief in cilia on the frustules of Diatoms, Mr. Wenham is as determined an opponent as he is to the like hypothesis respecting the Desmidieæ (*J. M. S.* 1856, p. 159), and he offers the following speculations on the cause of the movements:—"If caused by the action of cilia, such extremely rapid impulses would be required to propel the comparatively large body through the water, that surrounding particles would be jerked away far and wide; a similar effect would be observed if the propulsion were caused by the reaction of a jet of water, which, according to known laws of hydrodynamics, must necessarily be ejected with a rapidity sufficient to indicate the existence of the current a long distance astern. I consider that there is no ground for assuming the motions of the Diatomaceæ to be due to either of those causes. They are urged forward through a mass of sediment without displacing any other particles than those they immediately come in contact with, and quietly thrust aside heavy obstacles directly in their way, with a slow but decided mechanical power, apparently only to be obtained from an abutment against a solid body. In studying the motions of the Diatomeæ, I have frequently seen one get into a position such as to become either supported or jammed endways between two obstacles. In this case, particles in contact with the sides are carried up and down from the extreme ends with a jerking movement and a strange tendency to adherence, the Diatom seeming unwilling to part with the captured particle. Under these circumstances I have distinctly perceived the undulating movement of an exterior membrane; whether this envelopes the whole surface of the silicious valves I am not able to determine, nor do I know if the existence of such a membrane has yet been recognized. The movement that I refer to occupied the place at the junction of the two valves, and is caused by the undulation of what is known as the 'connecting membrane.' This will account for the progressive motion of the Diatomeæ, which is performed in a manner analogous to that of the

Gasteropoda. The primary cause, however, is different, and not due to any property of animal vitality, but arises, in my opinion, merely from the effects of vegetable circulation. I have observed several corpuscles of uniform size travel to and fro apparently within the membrane, which is thus raised in waves by their passage." Mr. Wenham follows up this explanation by a conjecture with respect to the rarer movements of the Desmidieæ. "As there are in these," he writes, "no indications of either external orifices or cilia, may not their locomotion be effected by the currents of protoplasm forcing their way between the primordial utricle and outer tunic, which will thus be raised in progressive waves if the investment happens to be in a suitably elastic condition." (See p. 5.)

The undulating movement of an exterior membrane thus indicated by Mr. Wenham, over the surface of Diatomaceous frustules, is doubtless identical with the current demonstrated by Siebold by means of indigo (*J. M. S.* i. pp. 196, 197). The latter states that the particles of this colouring matter which come in contact with the living *Naviculæ* are set into a quivering motion, although previously quite motionless; but this happens only along the lines of the four sutures, the particles adherent to other parts of the shield remaining motionless. "The indigo particles, which are propelled from the terminal towards the two central eminences, are never observed to pass beyond the latter: at this point there is always a quiet space, from which the particles of indigo are again repelled in an inverse direction towards the extremities. This proves that the linear sutures, as may in fact be seen, do not extend over the central eminences of the shield. The current at these clefts is occasionally so strong, that proportionally large bodies are set in motion by it." The sutures and clefts alluded to by Siebold, it should be understood, are not the sutures between the valves and connecting membrane, but the evident lines extending between the apparent pores on the valves, and which, to his apprehension, are actual fissures in the silicious envelope, by which "the delicate primordial membrane which lines the silicious shield can be brought into close relation with the external world." This belief in the presence of such fissures on the valves we have previously examined and shown to be unfounded. (See p. 41.)

Prof. Smith has the following remarks on this debateable point of the cause of the motions of Diatomeæ (*op. cit.* vol. i. p. xxiii):—"Of the cause of these movements, I fear I can give but a very imperfect account. It appears certain that they do not arise from any external organs of motion. The more accurate instruments now in the hands of the observer have enabled him confidently to affirm that all statements resting upon the revelations of more imperfect object-glasses, which have assigned motile cilia, or feet, to the Diatomaceous frustule, have been founded upon illusion and mistake. Among the hundreds of species which I have examined in every stage of growth and phase of movement, aided by glasses which have never been surpassed for clearness and definition, I have never been able to detect any semblance of a motile organ; nor have I, by colouring the fluid with carmine or indigo, been able to detect, in the coloured particles surrounding the Diatom, those rotatory movements which indicate, in the various species of true infusorial animalcules, the presence of cilia. I am constrained to believe that the movements of the Diatomaceæ are owing to forces operating within the frustule, and are probably connected with the endosmotic and exosmotic action of the cell. The fluids which are concerned in these actions must enter and be emitted through the minute foramina at the extremities of the silicious valves; and it may easily be conceived that an exceedingly small quantity of water expelled through these minute apertures would be sufficient to produce movements in bodies of so little specific gravity.

"If the motion be produced by the exosmose taking place alternately at one and the other extremity, while endosmose is proceeding at the other, an alternating movement would be the result in frustules of a linear form,—while in others of an elliptical or orbicular outline, in which foramina exist along the entire line of suture, the movements, if any, must be irregular, or slowly lateral.

"Such is precisely the case. The backward and forward movements of the *Naviculeæ* have been already described; in *Surirella* and *Campylodiscus* the motion never proceeds farther than a languid roll from one side to the other; and in *Gomphonema,* in which a foramen, fulfilling the nutritive office, is found at the larger extremity only, the movement is a hardly perceptible advance in intermitted jerks in the direction of the narrow end. The subject is, however, one involved in much obscurity, and is probably destined to remain, for some time to come, among the mysteries of Nature, which baffle while they excite inquiry."

The last clause of this quotation expresses the unsatisfactory state of the question; yet the foregoing examination will, we think, leave only three hypotheses deserving further inquiry: viz., 1. the existence of cilia, or, 2. of an undulating membrane; and 3. the operation of endosmose and exosmose, as a mechanical cause. To our apprehension, the presence of cilia, perhaps ranged only along the sutural lines, has not been completely disproved; and, on the other hand, considered as locomotive organs, cilia have the great advantage of analogy over the presumed undulatory membrane. Do not, indeed, the experiments with indigo, recounted by Siebold, suggest cilia to be the active agents of the movements recorded?

The rate of motion of the Diatomeæ is exceedingly languid and slow; sometimes it amounts to no more than an oscillating movement, with little or no change of place; and at another, the backward and forward movements are so nearly equal, that the frustule makes no appreciable advance. Prof. Smith has measured the rate of motion of some species, and remarks that, however vivacious and rapid they may at first sight seem, yet, when considered with reference to the high magnifying powers employed, and the consequent amplification of their movements, they are very slow. "I have noted the movements of several species with the aid of an eye-piece micrometer and a seconds watch, and found that one of the most rapid, viz. *Bacillaria paradoxa,* moved over $\frac{1}{200}$th of an inch in a second; *Pinnularia radiosa,* one of the slowest, over $\frac{1}{3400}$th of an inch in the same time; and that the same period was occupied by *Pinnularia oblonga* in traversing $\frac{1}{2000}$th of an inch, *Nitzschia linearis* $\frac{1}{2500}$th of an inch, and *Pleurosigma strigosum* $\frac{1}{2400}$th of an inch. Or, expressing the spaces and times by other units, we find that the most active required somewhat more than three minutes to accomplish movements whose sum would make one inch, and the slowest nearly an hour to perform the same feat."

Before quitting the subject of the movements of the Diatomeæ, we would briefly advert to the peculiar motion of some species, especially of *Bacillaria paradoxa.* The movements of this organism, as the specific name implies, are paradoxical, or very strange in character. Mr. Thwaites essayed to describe what indeed can be rightly apprehended only by personal observation, in the following words (*Proc. of Linn. Soc.* i. p. 311):—"When the filaments have been detached from the plants to which they adhere, a remarkable motion is seen to commence in them. The first indication of this consists in a slight movement of a terminal frustule, which begins to slide lengthwise over its contiguous frustule; the second acts simultaneously in a similar manner with regard to the third, and so on throughout the whole filament,—the same action having been going on at the same time at both ends of the filament, but in opposite directions. The central frustule thus appears to remain stationary, or nearly so,—while each of the others has moved with a rapidity increasing with its distance from the centre, its own rate of movement having been increased by the addition of that of the independent movement of each frustule between it and the central one. This lateral elongation of the filament continues until the point of contact between the contiguous frustules is reduced to a very small portion of their length, when the filament is again contracted by the frustules sliding back again as it were over each other; and this changed direction of movement proceeding, the filament is again drawn out until the frustules are again only slightly in contact. The direction of the movement is then again reversed, and continues to alternate in opposite directions, the time occupied in passing from the elongation in one direction to the opposite being generally about 45 seconds. If a filament while in motion be forcibly divided, the uninjured frustules of each portion continue to move as before, proving that the filament is a compound structure, notwithstanding that its frustules move in unison. When the filament is elongated to its utmost extent, it is extremely rigid, and requires some comparatively considerable force to bend it, the whole filament moving out of the way of any obstacle rather than bending or separating at the joints. A higher temperature increases the rapidity of the movement."

To this account Prof. Smith appends these observations:—"The motion here so accurately described is not essentially different from that noticeable in many of the free species of Diatomeæ, the peculiarity being that it is here exhibited in numerous united frustules; when observed in a band of one hundred or more frustules, the singular appearances assumed by the filament under the action of so many individuals moving at one time in apparent concert, and another in opposition, never fail to excite astonishment."

Mr. Thwaites's account conveys the impression that the movements are always regular: but this is not the case; for Mr. Ralfs tells us, by letter, that both Dr. Bailey and himself have convinced themselves that they are at many times irregular.

Dr. Donkin, in his description of a new species of *Bacillaria* he names *B. cursoria* (*J. M. S.* 1858, p. 27), has the following account of its singular movements:—"When the filament is in a quiescent state, the frustules are all drawn up side by side, their extremities being all in a line, thus forming a *group*. When a filament previously at rest resumes its activity, the movement is commenced by the *second* or *inner* frustule at one end of the filament gliding forward along the contiguous surface of the *first* or *outer* frustule until their opposite extremities overlap each other. This is soon followed by a similar movement of the third, fourth, and fifth, &c., all moving forward in the same direction, and each frustule gliding along the surface of the one preceding it, until they have extended themselves into a lengthened filament or chain. In the course of two or three seconds after this has been accomplished, a *retrograde* movement, exactly of the same character, begins to take place, and continues until the filament has retraced its course, and stretched itself out in a direction exactly opposite to the position it had previously occupied. This phenomenon is repeated again and again; and in this manner the whole group is kept in a state of activity for an indefinite period of time; and all the while, if no impediment produces irregularity, the *outer* or *terminal frustule*, next to which the movement commenced, *maintains a stationary and fixed position.*

"The rapidity with which each individual frustule moves is in direct ratio to its distance from the terminal *stationary* frustule, being most rapid at the opposite or moving extremity of the filament. On this account, most of the frustules, while the filament is moving to and fro, cross a line drawn at right angles to the middle of the long axis of the stationary frustule, at the same instant of time, afterwards shooting past each other like horses on a race-course.

"The force with which the filament moves is very great, so much so that I have observed it upset and shove aside a large frustule of *A. arenaria*, n. sp., at least six times its own bulk, obstructing its path. This force is, in a great measure, due to the rapidity with which the frustules move,—the time which a filament, even of considerable length, occupies in crossing the field of the microscope being only a few seconds.

"Light appears to be a necessary stimulus for the maintenance of this motion. When a filament in active motion is placed in the dark for a short period, and then examined, the movement is seen to have ceased, but again commences when the filament is exposed to the light for a short time. Is not this singular movement, with which the present species is endowed, a vital phenomenon, and independent of physical causes for its existence?

"When the moving extremity becomes entangled in any kind of substance intercepting its course, the opposite or stationary extremity commences to move, and continues to do so until the entangled extremity is set free; sometimes, in such instances, a frustule in the centre remains fixed, a movement of each half of the filament in opposite directions, on either side of it, taking place. But all these irregularities cease as soon as the impediment has been got rid of.

"These facts lead to the conclusion that the present species is a true *Bacillaria*, although *apparently* somewhat anomalous in the structure of its frustule. The gliding movement of one frustule over the contiguous one is the same as is observed in *B. paradoxa*; but it differs from this latter species in this essential particular, that the *whole* of its filament *moves on one side* of a *terminal frustule which is stationary*,—while, in *B. paradoxa*, *each half* of the filament moves in *opposite directions* on either side of a *central stationary* frustule."

The movement of one segment upon another is witnessed in other concatenate species, but in a less degree, where the medium of attachment is limited to a small space, as in those several genera having the alternate or opposite angles of their frustules connected by a link-like isthmus, *e. g.* *Diatoma*, *Fragilaria*, *Grammatophora*, &c.

Nutritive Functions;—Supposed Stomachs;—Circulation of Contents;—Respiration.—The nutrition of Diatomeæ is provided for primarily by the endosmotic and exosmotic action going on through the 'foramina' in the silicious epiderm, whereby fluid material laden with the matters necessary to build up the various elements of the endochrome is introduced into the organisms.

On the first appearance of a frustule, the endochrome is homogeneous and granular; but as time advances, granules are seen to congregate in certain parts, and globules or vesicles of various size speedily develope themselves, and either take up definite positions or are irregularly diffused. During these changes in the contents—during, indeed, the entire life of the cell, under the influence of light, oxygen is given off, and the gases with which it was united in various chemical compounds are appropriated to the purposes of the economy.

The very fact of the existence of the silicious epiderm, thrown off, it would seem, as an excretion from the organic membrane of the frustules, indicates the activity and energy of the nutritive functions,—a fact further demonstrated by the production of the 'connecting membrane,' and, in short, by the whole process of reproduction, whether by self-division or by sporangia. The silica present in the lorica must be taken up by the organism in a state of solution; and although the quantity of silica dissolved in water is inconceivably small, it is nevertheless sufficient to supply the material for the construction of millions of Diatomaceous shells, even in a short time, as the phenomena of reproduction and the rapid appearance of these structures as an appreciable powder, or as a colouring matter in water, prove. "It is probable," says Dr. Gregory (*J. M. S.* 1855, p. 2), "that as fast as the silex is extracted from the water by them, it is dissolved from the rocks or earths in contact with the water, so that the supply never fails;" and we may add, so that the quantity never accumulates beyond the very minute fractional portion chemists can detect.

Ehrenberg's untenable hypothesis of the presence of stomach-sacs and of an alimentary canal opening externally has received sufficient attention in the history already given (pp. 47, 48), of the nature of the contents of the Diatomeæ and of their investing lorica. Were other considerations needed, the absence at times of any such vesicles as Ehrenberg conceived to be gastric cells, their occasional coalescence, and the phenomenon of cyclosis or the circulation of the contents, each and all subjects of direct observation, might be appealed to as proofs of the errors that great naturalist fell into respecting the internal organization of the Diatomeæ.

The phenomenon of cyclosis has been observed by Nägeli in a species of *Navicula*, and in one of *Gallionella* (*Melosira*) (XV. 27), and by Prof. Smith in other Diatoms. This writer says (*op. cit.* i. p. xxi)—"In *Surirella biseriata* this motion has been more especially apparent; but I have also observed it take place in *Nitzschia scalaris* and *Campylodiscus scalaris*. This circulation has not, however, the regularity of movement so conspicuous in the Desmidieæ, and is of too ambiguous a character to furnish data for any very certain conclusions, save one, viz. that the Diatom must be a single cell, and cannot contain a number of separate organs, such as have been alleged to occupy its interior,—since the endochrome moves freely from one portion of the frustule to the other, approaching and receding from the central nucleus unimpeded by any intervening obstacle."

Schultze, in his contribution on the movements within the frustules of Diatomeæ (*Müll. Archiv*, 1858), represents them to occur in and along the finely granular threads into which the less fluid mucilaginous portion of the endochrome is drawn out. He compares the movements in character to those of the 'variable processes' or pseudopoda of Rhizopodes, and thereby assimilates the mucilaginous films of Diatomaceous frustules with the soft sarcode of those simplest animalcules,—a similarity countenanced by the now well-known fact of an Amœbiform phase in the cycle of development of some of the lower Algæ (*vide* section on Phytozoa). The cyclosis in plant-cells is no doubt rightly attributed to the operation of the vital processes of nutrition and of the so-called respiration, and primarily to the chemico-vital action proceeding by the medium of the chlorophyll-globules; and it seems most consonant with the teachings of science to assign the less active and less complete and regular internal movements of the Diatomeæ also to the similar vital forces,—the coloured corpuscles, it may be, acting here likewise as the prime mover. We are aware that the nucleus has been represented to be the first source of the movements in plant-cells, since the current seems to flow from and to return to it in many cases; but this phenomenon is explicable in another way, by admitting the disposition of the mucous threads as displayed by Schultze, extending as they do from the nucleus on all sides, and serving at the same time to limit and to direct the movements taking place within and by them. We have not adverted to ciliary action as the cause, for; so far as we can gather, Mr. Osborne and Mr. Jabez Hogg have failed to impress many naturalists with the fact of its existence and operation in Diatoms.

Lastly, Schultze remarks that, to see the mucilaginous threads and the internal movements, living and fresh specimens are needed; for they are soon arrested when the frustules are removed from their natural habitats, and are quite lost to vision when they become dry. Hence it is, no doubt, that no previous observer has detected and rightly apprehended the facts enunciated by Schultze.

The so-called function of respiration is evinced in the fixing of the carbon of the carbonic acid and in the disengagement of oxygen gas; but this is rather an act of nutrition, and resembles that silent and invisible disengagement of certain particles, and the rearrangement of others, which proceed in the formation and in the removal of worn-out tissues in higher animals.

Multiplication, Reproduction, and Development of Diatomeæ.—Among the modes of reproduction of the Diatomeæ, self-division has usually been accounted one, but erroneously so, since this process is no more than a multiplication of an individual cell, and completely homologous with the process of cell-fission exhibited in the construction of animal and vegetable tissues in general. The peculiarity in the self-division of the Diatomeæ, *i. e.* among the free simple beings, is, that the division is followed by separation; for each cell, instead of uniting with its neighbours in the formation of a tissue, commences an independent existence. Self-division in one direction, not followed by separation, produces the filamentary or concatenated Diatomeæ, whilst the abundant excretion of a mucus around the dividing frustules, and its persistence, give rise to the frondose genera, which make an approach towards the character of vegetable cellular tissue,—each cell, however, retaining an independent vitality greatly more pronounced than in the latter.

The process of self-fission or deduplication in this family resembles in all essential particulars that in other vegetable cells (XV. 28, *a*, *b*, *c*). Preparatory to its visible occurrence, or rather simultaneously with certain changes in the interior, the valves separate by the progressive growth of the connecting membrane. The nucleus within is observed to divide into two portions, each of which eventually becomes detached from the other, and, in Prof. Owen's language, serves as a centre of spermatic force, and induces an aggregation of the granules of the endochrome about it. Whilst this separation of the nucleus and of the general contents is going forward, the lining or primordial membrane of the cell becomes doubled inwards in the entire circumference along the line of division, and advances gradually until it at length forms a complete septum, cutting the original single cell into two. This septum is actually double; and in each lamina a deposit of silicious material speedily proceeds, so as to produce two new valves, each opposed to, and immediately continuous around its circumference with, one of the two original valves. Thus, on the completion of this process of deduplication, two frustules result, awaiting only the final act of separation to enter on an independent existence and to repeat the like series of phenomena, and so on through a seemingly almost endless chain, to perpetuate the existence of the particular species or individual. (See Meneghini's account of the process and peculiarities of self-division in this class, in the examination of the arguments for the animality of the Diatomaceæ, in a subsequent page.) The true nature, therefore, of this process of self-division being an extension, not a renewal, of individual life, has been justly represented by Mr. Thwaites as an act of gemmation, not of reproduction.

In the course of self-division, in some instances at least, a mucous or muco-gelatinous matter is thrown out around the frustules engaged. This circumstance did not escape the notice of Nägeli; and Prof. Smith (*Synopsis*, i. p. 62) has, after noting it in previous pages as a common phenomenon in the family, thus referred to it in the genus *Pleurosigma*:—"While self-division is actively going forward, the mucus generated by the dividing frustules is often so considerable as to produce the appearance and effect of a distinct frond, which assumes the form of a thin pellicle of some little tenacity. At other times, when the mucous secretion does not assume the continuity of a pellicle, it invests the individual frustule with a transparent envelope, which has the appearance of an exterior membrane, and has been sometimes mistaken for such. On one occasion I also met with the frustules of *P. Hippocampus* enclosed in mucous or gelatinous tubes, precisely like those of a *Colletonema*; but these conditions must be regarded, for the present at least, as temporary or accidental, and cannot be admitted into the specific or generic descriptions."

The process of self-division is affected in some unimportant particulars by the figure and habits of certain genera. Thus in one section of the *Melosireæ*, the frustules of which have convex ends, Mr. Ralfs points out (*A. N. H.* xii. p. 347) that the central line is more strongly marked, and seems to divide the frustule into two equal portions. It becomes broader, and at length double, and ultimately an intermediate growth separates the two halves of the frustule, which, during this process, do not increase in size; but when the intermediate space is equal to the diameter of the original frustule, two new frustules are formed, by the addition of two hemispheres on the inner sides of the separated portions. The outer silicious covering still remaining, the frustules are connected in pairs, and appear like two globules within a joint, as they are characterized by Harvey in *Melosira nummuloides*, and by Carmichael in *M. globifera*. The above description belongs more particularly to *M. nummuloides*; but the process in the other species of this section is the same: a series of changes, nearly similar, occurs in *Isthmia*.

"In this genus," the author quoted says, "the mode of growth is very curious. As in most of the Diatomeæ, the plant increases by a division of the frustules; but in this genus, as also in *Biddulphia* and *Amphitetras* (and in the *Achnantheæ*), two new frustules are formed within the old one, and as they enlarge, rupture it, when it falls off. In these the front portion is at first very narrow, and merely a broad line, but it increases greatly in breadth until the new frustules are fully formed." In this description and explanation the widening band or front portion mentioned is in fact the 'connecting membrane' of Prof. Smith, which, in the genera named, has an extra development, "an extension beyond the sutures of the valves," and also an unusual persistence, retaining the two frustules together after self-division, in such a manner that they seem to be enclosed within an original single frustule, just as Mr. Ralfs describes.

This longer persistence of the connecting membrane has been noted by Prof. Smith (*A. N. H.* 1851, p. 4), who writes—"In some cases, by the new, or rather semi-new frustules proceeding immediately to repeat the process [of self-division], the connecting membrane is thrown off and disappears; in others it remains for some time, linking the frustules in pairs, as in *Melosira* and *Odontella*."

Another peculiarity, again, not unfrequently obtains in this process of self-fission, viz. a departure from the prevailing law of similarity which exists between the new valve and the parent one with which it is united in the newly-created frustule. The newly-developed segment occasionally acquires slightly greater dimensions,—a fact best exhibited in the filamentous genera, since in them it gives rise to an evident irregularity in the chain, affecting its width. Yet, as Prof. Smith remarks (i. p. xxvi), "This increase is so small, that in a filament of many hundred frustules, the enlargement is scarcely appreciable. The rapid attenuation represented by some authors in the filaments of the *Fragilariæ* must therefore be attributed to the deceptive appearance presented by a compressed band when slightly twisted, the semblance of attenuation being thus given to the portions which are presented in an oblique direction to the eye of the observer.... Starting from a single frustule, it will be at once apparent, that if its valves remain unaltered in size, while the cell-membrane experiences repeated self-division, we shall have two frustules constantly retaining their original dimensions, four slightly increased, eight somewhat larger, and so on in a geometrical ratio, which will soon present us with an innumerable multitude containing individuals in every stage, but in which the larger sizes preponderate over the smaller; and such are the circumstances ordinarily found to attend the presence of large numbers of these organisms."

Mr. Ralfs has favoured us with the following remarks on this subject in letters. He writes (March 1856)—"In a recent number of the *Ann. Nat. Hist.*, Mr. Carter expresses his belief that the frustules of Diatomaceæ gradually become smaller by division, and that it requires the sporangial frustule from time to time to keep them the proper size. This I cannot admit; for any person who will take the trouble to watch a species of *Gomphonema* from its first appearance in spring, as a scarcely visible fringe to aquatic plants, will observe not only increase of mass, but also enlargement of the frustules. If Mr. Carter is right, the filament in *Fragilaria* would be very unequal: for instance, as the first-formed frustule could not decrease, and as its segments after division would always form the two ends of the filament, they should be the largest, then the adjacent valves of the two central frustules of the filament the next largest, and so on." In a subsequent letter the same distinguished authority writes:—"I see that Prof. Smith, in his *Synopsis*, p. xxvi, takes the contrary view to Mr. Carter, and considers that the frustules do not grow after they are fully formed, but that, in dividing, the new frustules may slightly increase in size. It is thus that he accounts "for the varying breadth of the bands in the filamentous species, and the diversity of size in the frustules of the free forms." If he is correct, his opinion is still more adverse to Mr. Carter's views respecting the frustules formed after self-division. But I doubt also the correctness of Mr. Smith's views. He himself states that "the enlargement is scarcely appreciable;" and yet we find a vast difference of size in the frustules of the same gathering. The filaments are so fragile in *Fragilaria*, and even in *Himantidium*, that it is very difficult to determine whether the frustules in the same filament do differ much in size, and whether, if they do, the variations are alternating or irregular, as would be the case if either Prof. Smith or Mr. Carter be correct.

The rate of production of specimens of Diatomeæ, even by this one process of simple self-division, is something really extraordinary. So soon as a frustule is divided into two, each of the latter at once proceeds with the act of self-division; so that, to use Prof. Smith's approximative calculation of the possible rapidity of multiplication, supposing the process to occupy, in any single instance, twenty-four hours, "we should have, as the progeny of a single frustule, the amazing number of one thousand millions in a single month,—a circumstance which will in some degree explain the sudden, or at least rapid appearance of vast numbers of these organisms in localities where they were, but a short time previously, either unrecognized or only sparingly diffused."

This multiplication by self-division now described, is generally supposed, after a time, so to speak, to exhaust itself, and thereby to render necessary other plans of propagating species. That some other modes do really exist is suggested by the fact of the considerable variations of size of frustules of the same species obtained at one time from the same locality, and moreover by diversities in the relative distance and in the delicacy of the striæ of the surface. One such mode of propagation Mr. Thwaites has demonstrated to consist in the production of sporangial frustules by a process of conjugation analogous to that in the Desmidieæ and many other Algæ.

CONJUGATION.—The method of *conjugation,* although essentially alike in all cases, exhibits several important modifications in the genera of this family. These were more or less clearly perceived by Mr. Thwaites, who spoke of them as exceptional varieties; but to Mr. Smith belongs the credit of reducing all of them under four principal forms: viz., 1. That in which two parent frustules produce two sporangia by conjugation, as in *Epithemia, Cocconema, Gomphonema, Encyonema,* and *Colletonema.* 2. Two parent frustules generate a single sporangium, *e. g.* in *Himantidium.* 3. "The valves (vol. ii. p. xii) of a single frustule separate, the contents set free rapidly increase in bulk, and finally become condensed into a single sporangium. This may be seen in *Cocconeis, Cyclotella, Melosira, Orthosira,* and *Schizonema.*

"In *Melosira nummuloides, M. Borrerii,* and *M. subflexilis,* the second valve of the conjugating frustule is rarely found united to the mucus surrounding the sporangium, the conjugation taking place only in the last frustule of the filament; but in *Melosira varians* and *Orthosira orichalcea,* conjugation taking place throughout the entire filament, both valves are usually found adherent to the sporangium or its surrounding mucus.

"From a single frustule, as in the last method, two sporangia are produced in the process of conjugation: this takes place in *Achnanthes* and *Rhabdonema.*"

In describing the process as generally as possible, we cannot do better than follow Mr. Thwaites's account, although it is illustrated by an example taken from the first category of variations. "For the most part," he tells us, "conjugation in the Diatomeæ, as in the Desmidieæ, consists in the union of the endochrome of two approximated fronds,—this mixed endochrome developing around itself a proper membrane, and thus becoming converted into the sporangium. In a very early stage of the process, the conjugated frustules, as in *Eunotia turgida,* have their concave surfaces in nearly close apposition (XI. 1), and from each of these surfaces two protuberances arise, which meet two similar ones in the opposite frustule (XI. 3); these protuberances indicate the future channels of communication by which the endochrome of the two frustules becomes united, as well as the spot where is subsequently developed the double sporangium, or rather the two sporangia. A front view of two frustules at the same period shows each of them to have divided longitudinally into two halves (XI. 4), which, though some distance apart, are still held together by a very delicate membrane: this, however, soon disappears.

"The mixed endochrome occurs, at first, as two irregular masses between the connected frustules; but these masses shortly become covered, each with a smooth cylindrical membrane,—the young sporangia, which gradually increase in length (XI. 5, 6), retaining nearly a cylindrical form (XI. 7), until they far exceed in dimension the parent frustules, and at length, when mature, become, like them, transversely striated upon the surface (XI. 8). Around the whole structure a considerable quantity of mucus has, during this time, been developed, by which the empty frustules are held attached to the sporangia (XI. 5-8)."

The variations in the process are alluded to in the following extracts from the same eminent observer's papers:—"In different genera, slight variations are met with in the method of conjugation: thus, in some species of *Gomphonema* the sporangia lie in a direction parallel to the empty frustules, instead of across them, as described in *Eunotia turgida*. Again, there are examples (in *Gomphonema minutissimum* and *Fragilaria pectinalis*) where, instead of the conjugated frustules separating into two halves, only a slit appears at one end, to serve for the escape of the endochrome. Instead also of the pair of conjugated frustules producing between them two sporangia, they may develope but a single one, as happens in *Fragilaria pectinalis*. In this species, too, the sporangium, at first cylindrical, soon assumes a flattened, somewhat quadrangular form, and in many cases undergoes fissiparous division before it has put on the exact appearance of the frustule of a *Fragilaria*.

"The *Melosireæ* (*Gallionellæ*, Ehr.) and the *Biddulphiæ*," Mr. Thwaites remarks, "would seem, in their development of sporangia, to offer an exception to most Diatomeæ; for in those genera no *evident* conjugation has been seen. However, something analogous to it must take place; for, excepting the mixture of endochromes of two cells, the phenomena are of precisely similar character. Thus, instead of the conjugation of two frustules (XV. 29, *a*, *b*, *c*, *d*, 32, 33), a change takes place in the endochrome of a single frustule,—that is, a disturbance of its previous arrangement, a moving towards the centre of the frustule, and a rapid increase in its quantity: subsequently to this it becomes a sporangium; and out of this are developed sporangial frustules, as in the other Diatomeæ. In a single cell, therefore, a process physiologically precisely similar to that occurring between two conjugating cells takes place; and it is not difficult to believe, taking into view the secondary character of cell-membrane, that the two kinds of endochrome may be developed at the opposite ends of one frustule, as easily as in two contiguous frustules, and give rise to the same phenomena as ordinary conjugation."

Further, in his notes on *Schizonema subcohærens*, Mr. Thwaites writes,—"The sporangia of this species are produced by the conjugation of a pair of frustules outside the filaments; but sporangial frustules are frequently found in a filament intermixed with ordinary frustules, from which they differ only in size."

Dr. Griffith and Mr. Carter, moreover, have portrayed peculiarities in the conjugating process, which Prof. Smith can neither explain nor confirm, and is equally unable to reduce under either of the leading variations he has defined. The first-named naturalist stated that in the conjugation of a species of *Navicula* (*amphirhynchus*?) a silicious sheath enveloped the sporangial frustule, indestructible by heat and nitric acid. "It is," he writes, "colourless, elongate, rounded at the ends, and furnished with coarse transverse striæ or depressions, through which the line of fracture runs when the object is crushed." This account seems to Prof. Smith erroneous; and he suggests that this sheath "may probably have been an *appearance* resulting from the condensation and corrugation of the mucus developed around the reproductive body." This conclusion Dr. Griffiths declares untenable, since no kind of mucus will resist the action of a red heat and nitric acid. The specimen examined was, besides, not an isolated one, but hundreds such were present" (*A. N. H.* xvi. 92).

Prof. Smith thus alludes to Mr. Carter's views:—"The circumstance dwelt upon by Mr. Carter as having an important bearing upon the *rationale* of the process, viz. that one of the conjugating frustules is invariably smaller than the other, is altogether at variance with my experience, and is totally irreconcilable with the process as it occurs in the genera mentioned under the third and fourth classes. I am therefore disposed to believe that the difference in size noticed by Mr. Carter was a mere accidental diversity, and of no essential signification."

The four typical modes of conjugation established by Prof. Smith have their occurrence thus explained (*Synops.* ii. p. xiii):—"The functions of life and growth are not suspended during the act of conjugation; and in consequence self-division may take place at any stage of the process which accompanies the formation of the reproductive body, or the latter process may intrude upon, or arrest any step in the progress of self-division.

"In the first mode of conjugation, as occurring in *Epithemia*, &c., self-division may be regarded as in the earliest stage of its progress, which merely involves the separation of the endochrome of the parent frustules into two portions, but does not include such a differentiation of these portions as renders them capable of the conjugative act: the endochrome capable of conjugating with these segregated portions must be sought for in other frustules; hence the process in these genera involves the presence of two parent frustules, and results in the production of two sporangia.

"In the second mode, met with in *Himantidium*, the progress of separation is arrested at a still earlier stage; no differentiation has taken place, and conjugation intervening, necessitates the union of the entire contents of two parent frustules to form a single sporangium.

"In the third mode, the progress of the separation of the endochrome in the parent frustule must be considered as so far advanced that complete differentiation has taken place. In every respect but the formation of new valves, self-division has been completed; the incomplete frustules are therefore prepared for conjugation, which, intervening at this stage, leads the observer to believe that but one frustule has been concerned in the production of the single sporangium. This we see in *Melosira* and the other genera mentioned under this class.

"And lastly, self-division occurring during the progress of conjugation, the endochrome becomes segregated in the very act of intermingling, and a single frustule, whose contents have been already differentiated, gives rise to two sporangia, as in *Achnanthes* and *Rhabdonema*.

"Nor is the self-dividing disposition in all cases permanently arrested by the complete formation of the sporangium. Having assumed the form of the parent frustules, with a great increase in size (the enlargement in dimensions being in some cases due to the accumulation of the contents of the two conjugating frustules, and in others to a rapid assimilation of nutritive material from the surrounding medium), the sporangial frustule immediately submits to self-division, and by the repetition of this act developes a series of frustules equal in size to the original product of the conjugating process. This is notably the case in the filamentous species, as may be easily seen in *Melosira*, in *Orthosira*, and in *Himantidium*. How far this self-division may be carried in the sporangial frustules is at present unknown; it is probably of short duration, as we rarely meet with any considerable number of frustules characterized by the enlarged size of the sporangial form. In most cases an arrest of growth, and consequently of self-division, seems immediately to follow the complete formation of the sporangia, and the reproductive body assumes the quiescent character which belongs to the seed of the higher plant, its vital function remaining dormant until circumstances favour its further development and the production of the young frustules of which it is the destined parent.

"In the gathering of *Cocconema Cistula* made in April 1852, which contained numerous instances of the conjugating process, I observed the frequent occurrence of cysts enclosing minute bodies, variable in their number and size, and many of which had the outline and markings of the surrounding forms, and were obviously young frustules of the *Cocconema*. It would appear from the figures [appended to this account], that the production of the young frustules is preceded by the separation and throwing off of the silicious valves of the sporangium, and the constriction or enlargement of its primordial utricle, according to the number of young frustules originating in its protoplasmic contents. In this gathering, forms of every size intermediate between the minutest frustule in the cyst and the ordinary frustules engaged in the conjugating process were easily to be detected; and the conclusion was inevitable, that the cysts and their contents were sporangia of the species with which they were associated, and indicated the several stages of the reproductive process."

Since the preceding account of conjugation was written, a valuable, although not a very lucid, contribution on the subject has appeared by Dr. Hofmeister, in the Reports of the Saxony Natural History Society for 1857, and has been translated by Prof. Henfrey in the *A. N. H.* for January 1858. From this we extract the following as supplementary to the previously-written history of the conjugation-process and of self-fission, as well of the Desmidieæ (p. 11) as of the Diatomeæ:—

"Conjugation is far more rarely met with in the Diatomeæ than in the Desmidieæ. It appears that this process occurs here only at particular epochs, differing according to the seasons, happening simultaneously in all individuals, and quickly completed. Frequently as indications of conjugation having taken place have been met with (the occurrence of individuals of the same species, of remarkable diversity of size, side by side, in free Diatomeæ, *e. g. Pinnularia viridis, Surirella bifrons, Staurosigma lacustre,* all the year round, besides the occurrence of shorter or longer rows of cells of about double the diameter, in the bands, of the forms remaining connected by the lateral surfaces, *e. g. Melosira, Podosira*), yet it has seldom happened that they have been met with in the moment of conjugation.

"Since the classic researches of Thwaites upon this subject, the knowledge of it has on the whole been but little advanced by the observations of Focke (conjugation of *Surirella*), Griffith (conjugation of *Navicula*), W. Smith and Carter (conjugation of *Cocconeis, Cymbella, Amphora*). The following cases have been observed:—"Formation of a single conjugation-cell, dividing very soon after its origin: in *Himantidium pectorale, Cymbella Kützingiana, Cocconeis Pediculus, Cocconeis Placentula, Gomphonema lanceolatum, Schizonema Grevillii, Orthosira orichalcea, O. Dickiei,* remarkable from the repeated throwing-off of the coats of the conjugation-cell, the cracked halves of which clothed the conical ends of the conjugation-cell in shape of funnels; *Orthosira varians, Surirella bifrons,* and a *Navicula* not specifically determined. Here belongs also the only conjugation of a Diatomacean that I have seen, that of *Cyclotella operculata*, conjugation-cells of which, with adherent empty coats of the mother-cells, I found abundantly in ditches of a marshy meadow not far from Leipsic, in October 1852. They were not distinguishable in any essential respect from the *Cyclotella Kützingiana* figured by Thwaites.

"Next to these cases of the formation in the first place of only one conjugation-cell, come a series of observations in which two new cells were seen between the empty conjugated mother-cells, without any convincing evidence being offered of a division of the mother-cells having occurred just before conjugation, as in the cases hereafter to be mentioned,—where, rather, the position of the empty cells in relation to the conjugation-cells, and the affinity of the forms in question to some in which the entire development has been observed, render it probable that the unicellular condition of the conjugation-cell has hitherto escaped observation. In this group are to be counted *Cocconema lanceolatum, C. Cistula, Gomphonema dichotomum, G. lanceolatum, G. marinum, Achnanthes longipes, Rhabdonema arcuatum, Colletonema subcohærens.*

"In a smaller number of Diatomeæ, species of the genera so nearly allied together, *Epithemia, Cymbella,* and *Amphora,* the conjugation is immediately preceded by a division of the mother-cells into two, analogous to the division of the cells of *Closterium rostratum* when about to conjugate. This division is longitudinal, taking place exactly as in the vegetative division in *Cymbella Pediculus, Amphora ovalis,* and *Epithemia Sorex,* but transverse and in a direction crossing that of the vegetative division in *Epithemia turgida, E. gibba,* and *E. verrucosa.*

"Recent observations show distinctly that the conjugation of the Diatomeæ agrees in all essential points with that of the Desmidieæ. When a cell is about to conjugate, there is produced in it a coat round the entire contents, accurately lining the old membrane, but not adhering to it. The growth of this coat cracks the old cell-membrane exactly in the same way as occurs in vegetative division. From the fissure the young, smooth coat emerges, in the form of a vesicle, and unites with the similar structure produced by a neighbouring cell. Al. Braun thought it must be assumed, from Thwaites's observations, that the primordial utricles of the two conjugating Diatomean cells united; but that this is not the case, and that a soft and flexible cell-membrane, protruded from the cracked, rigid, old shell, encloses the contents destined to be blended with those of the neighbouring cell, is distinctly shown by Smith's figure of *Rhabdonema arcuatum,* and Carter's of *Cocconeis Pediculus* and *Amphora ovalis.* The introductory part of the conjugation is distinguished in no respect from the vegetative cell-division in *Epithemia Sorex, Amphora ovalis* and *Cymbella Pediculus,* and, further, in *Closterium rostratum*; in *Epithemia turgida, gibba,* and *verrucosa,* only by a different position of the wall dividing the mother-cell; in the rest of the Diatomeæ and Desmidieæ, by omission of the formation of septa,—frequently, also, by one-sided dehiscence of the cracked mother-cell, whose shells remain still connected at one side.

"Thwaites's observations established that the cell produced from the conjugation of two cells of a Diatomaçean, very soon after its origin, assumed the form of the mother-cell, becoming distinguishable from it almost solely by being twice as large. Smith has endeavoured to render it probable that the colonies of young individuals, enclosed in a cyst, of *Cocconeis Cistula, Gomphonema dichotomum,* and *Synedra radians,* some of which he found associated with conjugated, full-grown individuals, must have originated from the division of the spores (sporanges of English authors). This hypothesis has much in its favour, but, in the present condition of our knowledge, it is inexplicable where the silicious shells of the spore-cells remain. However this may be, there is no doubt of the occurrence of cysts of this kind. In the same pools of a marshy meadow which repeatedly furnished me with conjugated individuals of *Cyclotella* late in autumn, I found, in early spring of two successive years, globular cells, each of which enclosed a great number (32 to 40) of small individuals of the same species. The walls of these cells appeared sharply defined internally and externally; the contents of a thin, fluid nature.

Structures similar to those represented by Smith, of *Synedra radians*, occurred in extreme abundance in the end of the autumn of 1854, in company with *Synedra Ulna*. Here the cells, which, like those observed by Smith in the allied species, had a diseased aspect and an abnormal arrangement of the coloured contents, were imbedded in a granular jelly, of a reddish colour by transmitted light. I very much doubt whether these last were in a condition capable of further development; while in reference to the cysts of *Cyclotella operculata*, I share Smith's opinion.

"The establishment of the assertion that the commencement of conjugation in the Desmidieæ and Diatomeæ is but little distinguished from the commencement of vegetative cell-division, renders some discussion of the latter requisite. Pringsheim has already directed attention to the resemblance of this process in the Desmidieæ to the vegetative cell-multiplication of the joints of *Œdogonium*. In fact, it is an absolutely general phenomenon in the true Desmidieæ, so far as observation reaches, that the older parts of the membrane of a cell about to divide, do not, as in other cases (for example, in Zygnemeæ), regularly increase in size with the parent-cell by growth in all directions; but the older, outer layers of the integument split open with an annular crack at the equator of the cell, shortly after (or during?) the division. They still remain sticking on, covering the ends of the cell with a thick envelope, but become removed gradually further apart by the interposition of new cellulose between their fractured edges. The interposed new coat is the direct continuation of that which lines the internal surface of the cracked halves of the old shell. It is the margins of the half-shells which constitute the rings, parallel to the end-surfaces, upon the cylindrical lateral surfaces of the cells of *Hyalotheca dissiliens* and *H. mucosa*, the wrinkled projections of the membrane in the middle of the deep constriction of the cell of *Micrasterias* and the large *Euastra*, of the flat constriction of the cell of *Docidium*, as also the ring at the equator of the external surface of *Closterium*: in *Closterium* and in *Docidium*, frequently as many as six may be counted,—a phenomenon which, in *Docidium truncatum* and the large *Closteria*, may be recognized at first sight as dependent upon a number of halves of cracked cells regularly encasing their successors.

"The dehiscence of the coat of the dividing cell is, in all observed cases, preceded by the formation of the septum dividing the cell into two halves (*Cosmarium margaritiferum*). The gradual development of this from the margin of the cell-wall inwards, as a gradually-widening annular fold of the innermost layer of the integument, has not yet been observed, and, from analogy with the processes in *Œdogonium*, is scarcely probable. But, as in *Œdogonium*, the contents of the cell may be contracted, before the formation of the septum, into two masses, in contact, but separated by a sharp line of demarcation (two contracted daughter-cells imperfectly cut off from one another, still adhering together at the place of constriction).

"From the half-shells of cells of the same *Docidium* which dehisced under the eye of the observer, emerged, within half-an-hour, to the extent of $\frac{1}{5}$th or $\frac{1}{4}$th of the length of the half-shells, the daughter-cells, still intimately connected at the point of contact. They could henceforth be perceived to be enclosed by a cellulose coat, firm although delicate. Treated with reagents strongly extracting water, such as glycerine, one or both of the extruded pieces frequently drew back into the halves of the shells of the mother-cell, the projecting pieces of membrane becoming doubled inwards. The just-emerged coats of the daughter-cells of *Docidium* did not take a blue colour when treated with iodized chloride of zinc, while the old halves of the membrane of the divided cell assumed the blue colour immediately.

"In *Cosmarium margaritiferum* and *Staurastrum dejectum*, it may be easily observed that a slight elongation of the isthmus, and the formation of a septum passing across the middle of this, precede the appearance of new half-cells in the deep constriction. It is after the appearance of the septum that the old wall of the mother-cell breaks by an annular fissure exactly at the place where that septum is formed. The two halves of the old cell-coat are then separated by the bulging-out of the younger, inner layers of membrane, not firmly adherent to the old portions. The new halves are at first lined only by protruded portions of the pellicle of their contents (outermost layer of the parietal coats of protoplasm) belonging to the older half-cells; from the moment only of the dehiscence of the old cell-coat, does a portion of the granular contents of the older cell-halves make its way into the new emerging halves.

"In like manner, doubtless, occurs the cell-division of *Micrasterias*, of the large forms of *Euastrum*, *Cosmarium*, *Staurastrum*, and other Desmidieæ, only that they have not been observed completely, because these larger Desmidieæ very seldom multiply by division out of their natural stations. The cell-division of the Diatomeæ that have hitherto been observed in vegetative multiplication, differs in essential points from that just described.

"When a cell of *Navicula* (*Pinnularia*) *viridis* is about to divide, there appears upon one of the secondary sides (front view of English authors), parallel to the primary sides (the furrowed faces of the cell having an elongated elliptical outline), an annular rim, which, growing gradually inwards, constricts the contents of the cell by an annular furrow, in a manner exactly similar to that of the commencement of cross-division in a cell of *Cladophora*. When a cell in this state is treated with substances producing slight endosmosis (for instance, a weak solution of carbonate of ammonia), the contents retract on both sides from the annular rim, and constitute two completely separate cell-like structures (halves of a primordial utricle), each of a very long ellipsoidal form, and each lying close against one of the primary sides (*faces* of halves) of the cell. When the annular rim has grown inwards to about the sixth part of the shortest diameter of the cell, its development is arrested. In natural conditions, this stage is succeeded by the retraction of the primordial utricle from it. Each of these halves of the cell-contents becomes clothed, on the side turned away from the primary side of the cell, with a new membrane, which soon exhibits the first indications of the peculiar thickening ribs and nodules of one of the primary sides of our *Pinnularia*. The cell has now completed its division. Seen from one of the secondary sides, it contains two new individuals, equal to the mother-cell in length and breadth, but only possessing one-third of its thickness. The externally-situated primary side of each of them is the old primary side of the mother-cell, to which we must imagine the newly-formed membrane of the daughter-cell closely adherent at all points. Perhaps the narrow secondary sides of the new cells may be in the same condition. But the contiguous primary sides of the daughter-cells are totally new structures, which, developed rapidly, in a short time become similar to the old primary sides in every part. The two daughter-cells are at first held together by the broad middle piece of the secondary sides of the mother-cell, bearing the above-mentioned annular rim inside. The contents of the intermediate space consist of a transparent fluid destitute of any solid structures, doubtless pure water. The two daughter-cells are finally set free by the gradual 'weathering' of the zone-membrane which holds them together. The division of *Surirella bifrons* takes place exactly in the same way. An essentially similar kind of vegetative multiplication is widely diffused, if not general, in the Diatomeæ. The well-known phenomenon of the formation of a tubular membrane, often impregnated with silex, and elegantly dotted or areolated, connecting the two segments of *Isthmia*, *Melosira*, &c., depends upon the same process.

"An analogous case is met with in the formation of the spores of *Pellia epiphylla*. The mother-cell here produces six ridges of cellulose projecting inward from the internal wall, intersecting at an angle of 60°; these ridges grow in toward the middle point of the cell, like the annular ridge of *Cladophora* at the commencement of cell-division. When these projecting ridges have attained the breadth of a fourth part of the transverse diameter of the mother-cell, the cell-contents divide into four parts, which, retracting from one another and from those ridges, occupy the four chambers of the cell, each of which is vaulted externally and bounded laterally by three of the ridges,—here becoming coated with a membrane and developed into a spore, while the tetrahedral space in the middle of the cell, bounded by the six ridges, remains filled only with watery fluid. The spores become free by the solution of the enveloping part of the membrane of the mother-cell. The resemblance of this process to the vegetative multiplication of *Navicula* consists in the interruption of the division of the cell by the formation of septa, and the subsequent completion of the daughter-cells by secretion of membrane on the external surface of contracted portions of the contents of the mother-cell. A deviation occurs in the circumstance that in *Pellia* the segment of the coat of the mother-cell which is in contact with the external surface of the daughter-cell becomes dissolved, while in *Navicula* it persists and remains most intimately connected with the daughter-cell.

"The newly-formed parts of the cell-coat facing together in the division are, in the Diatomeæ, and still more clearly in the Desmidieæ, perfectly smooth and even for some time after their production; it is subsequently that they obtain the often very considerable tubercles and spines, consisting principally of cellulose. The same applies to the processes upon the outer integument of the spores of *Euastra*, *Cosmaria* and *Staurastra* produced in the conjugation. These phenomena, as also the autumnal secretion of jelly by many of the Desmidieæ, deserve more notice than they have hitherto attracted in connexion with the theory of the life of the vegetable cell. Still more remarkable behaviour is displayed by the cell-coat of an organism which I refer only doubtfully to the Desmidieæ. In many pools about Leipsic, in which Desmidieæ abounded, occurred large, accurately spherical, thick-walled cells, some as much as ·05 millim. in diameter, rich in chlorophyll, which not only lined the internal wall as a connected granular layer, but—as in many Desmidieæ—formed groups, distributed, in the interior of the cell, in a system of radially-arranged plates, which presented a stellate appearance when seen from the side. It would be no great stretch of imagination to regard these cells as the conjugation-spores of a large Desmidiean. But these spores are all spiny, with the single exception of those of *Xanthidium armatum*. This very striking form occurs but rarely with us, having hitherto been found only in a single locality, while these globules are as common as they are abundant, and are often found in great numbers in forest pools, which harbour, in addition to them, only very small Desmidieæ. But such a supposition is still more decidedly negatived by the circumstance that the cells in question are sometimes found dividing into two. This renders it in the highest degree probable that they are independent organisms—Desmidieæ without a central constriction, which may form the commencement of a series of forms terminating in *Micrasterias*.

"These cells frequently appear surrounded by a wider coat, inside which the cell then floats freely, enclosed by its own closely-investing coat. Several such empty coats are often met with, even as many as six sticking one inside another. Close investigation shows that the broader empty coats have an orifice, towards the border of which the membrane grows gradually thinner. These holes have not the aspect of perforations of the outer walls through external injury; they rather resemble the orifices of the walls of *Cladophora*, through which the swarming-spores escape. It might be conjectured that the plant multiplied by swarming-spores, and that solitary ones becoming developed inside the empty coat of the mother-cell gave rise to that appearance; but this is contradicted by the great frequency of their occurrence, as also by the circumstance that we never find a number of green cells inside one cell-coat. It is more probable that the contents of the cell contract, and become coated with a new membrane, when the old one is perforated,—by unknown causes, which perhaps lie in the course of development of the species.

"If we seek to bring the phenomena introductory to vegetative cell-multiplication under one point of view with the preparations for conjugation, we find that, in the Desmidieæ, in both cases a new membrane is formed around the total contents of the cell, which indeed lies close upon the old coat at all points, but by no means adheres to it, as we are accustomed to conceive of the so-called layers of thickening of the cell-wall. The growth of the young membrane cracks the stronger old one—in vegetative cell-multiplication always in an annular form, in conjugation, mostly in a one-sided manner, with a valve-like slit (*Hyalotheca dissiliens*; *Closterium*). At this stage first occurs a distinction between the two processes of development,—the formation of a septum taking place in cell-division, while in conjugation the protruding part of the young membrane continues to enlarge outwards, without, in many cases, any separation of the contents into two halves taking place. The younger, innermost layer of membrane remains with that portion lining the old cell-coat, sticking wholly in this in *Hyalotheca*, *Bambusina*, *Cosmarium*. But even in individuals of species of the last genus it sometimes occurs, in *Tetmemorus* and *Closterium* (e. g. *C. acutum*) as a rule (although by no means without exception), that the ends of the connected inner coats of the conjugating cells draw themselves out of the cast-off shells of the mother-cells, in extreme cases entirely; so that the cell originating by the blending of the internal coats of two individuals (inside which the spore is formed) becomes capable of being rounded off into a sphere.

"Both the cell-division and the preparation for conjugation of Zygnemeæ are distinguished from the processes in Desmidieæ by the circumstance that in the former the wall of the oldest cells grows in its entire mass, and does not allow the younger layers of membrane to protrude through fissures or slits.

"In the Diatomeæ, lastly, the division into two, like the conjugation, takes place, seemingly, in all cases, through and after a preparatory contraction of the contents or separate portions of the contents of the cells; and in not a few cases the conjugation takes place during, and is accompanied by, division of the contracted contents into two portions. What import for the life of the species has the conjugation of the Zygnemeæ, Desmidieæ, Palmelleæ (*Palmoglœa*), and Desmidieæ? Our knowledge of the race of Algæ, so importantly advanced by the labours of Pringsheim and Cohn, should allow a more positive answer to this question than that inquirer, to whom the study owes most brilliant acquisitions, is inclined to give. The idea of sexuality of the lower Algæ depends principally upon the perfectly justifiable, but still only analogical conclusions which, starting from the observations made during a century on the Phanerogamia, have advanced, through the intermediation of those, less numerous, on the Vascular Cryptogamia and Muscineæ, and the facts established in *Fucus* by experiment of artificial separation or union of the sexes, to the *Œdogonia*, *Vaucheria*, *Sphæroplea* and *Volvox*. Pringsheim's declaration, that physiological questions of such a kind as the necessity of the action of the fecundating matter in generation can only be certainly decided by the observation of morphological processes, will not be adopted. Experiment has long ago proved the existence of sexes in the Phanerogamia, before the penetration of the pollen-tube into the ovule, and its relation to the germinal vesicle, had been made out,—observations which that theory really no longer required for the establishment of its main question. And if, among so many confirmatory experiments, a few negative results present themselves, in what branch of human knowledge do we not meet with similar phenomena? The general rules of evidence hold good in such cases.

"The same analogies, then, which lead us to recognize a fecundation in the penetration of the spermatic body of *Œdogonium* into the mother-cell of the spore, in the mixture of that body with the contracted contents of the mother-cell of the spore (with Pringsheim's 'fecundation-globule'), must necessarily lead us to regard conjugation as a fecundation. It is distinguished from the process in *Œdogonium* only by the fact that the portions of cell-contents which become blended into one cell are of equal size; and that there is not one of them provided with apparatus by means of which, like the spermatic body of *Œdogonium* by its cilia, it is moved onward until it reaches the cell to be fecundated,—both points, evidently, of no essential importance.

"The sporangial frustules differ in general from the parent forms not merely in size, but also in the number of striæ or of other markings, and to some slight degree in outline. Such variation, M. Thuret contends, proves the phenomenon of conjugation to be, not a true mode of reproduction, but only 'a second mode of multiplication of frustules, very curious and very abnormal.'

"In the immature condition, we are informed by Mr. Thwaites, it happens that the sporangia in many species resemble in general characters the mature frustules of another species or even of an allied genus. Thus the sporangia of *Gomphonema minutissimum* (XI. 17) and of *G. dichotomum* have a close resemblance to the frustules of *Cocconema*. On the other hand, in some genera, as in *Cocconema*, the sporangia take on at once the exact characters of the ordinary frustules, from which they differ only in their exceeding that of the majority of the latter in dimensions.

"When a sporangium in a transitional condition is like the frustule of another genus, we are assisted in distinguishing its true nature and affinity, oftentimes, by the persistence of the mucus diffused around it; or by continued observation we may witness its assumption ultimately of its true specific characters, including the development of its pedicle or stalk, where the possession of such an organ is a characteristic (as in *Gomphonema*)."

The above fact suggests it as very probable that transitional forms have been described as particular species, or located in wrong genera. Thus Mr. Thwaites thinks that Kützing's *Epithemia vertagus* is no other than the sporangium of *Eunotia turgida*, and also that the enlarged frustules of the *Melosireæ*, which that same writer had conjecturally regarded as reproductive bodies, are in fact the sporangial product of conjugation, and give rise to a chain of frustules larger than those from which they had themselves originated.

The subsequent history of the sporangial frustules on being matured is not satisfactorily made out. Prof. Smith has the following on the question (*J. M. S.* 1855, p. 131):—"The ordinary Diatomaceous frustule seems to owe its production to the protoplasmic contents of the sporangial frustule formed by the process of conjugation. These sporangia, like the seeds of higher plants, often remain for a long period dormant, and are borne about by currents or become imbedded in the mud of the waters in which they have been produced, until the circumstances necessary to their development concur to call them into activity. At such times their silicious epiderms open to permit the escape of the contained endochrome, which is resolved into a myriad of embryonic frustules; these either remain free or surround themselves with mucus, forming a pellicle or stratum, and in a definite but unascertained period reach the mature form of the ordinary frustule," when their further growth appears almost entirely arrested by the production of the silicious coat, and when multiplication by self-division provides for the continuation of individual life. To continue the quotation, "The size of the mature frustule before self-division commences is, however, dependent upon the idiosyncrasy of the embryo, or upon the circumstances in which its embryonic growth takes place; consequently a very conspicuous diversity in their relative magnitudes may be usually noticed in any large aggregation of individuals, or in the same species collected in different localities."

The belief that the contents of the sporangial frustules resolve themselves into a 'brood' of Diatoms, having the same form and specific characters as the original parent-cells, Prof. Smith establishes by the following observations made by himself (*Synopsis*, vol. ii. p. xv):—"In the gathering of *Cocconema Cistula* made in April 1852, which contained numerous instances of the conjugating process, I observed the frequent occurrence of cysts enclosing minute bodies variable in their number and size, and many of which had the outline and markings of the surrounding forms and were obviously young frustules of the *Cocconema*. It would appear that the production of the young frustules is preceded by the separation and throwing off of the silicious valves of the sporangium and the constriction or enlargement of its primordial utricle, according to the number of young frustules originating in its protoplasmic contents. In this gathering, forms of every size, intermediate between the minutest frustule in the cyst and the ordinary frustules engaged in the conjugating process, were easily to be detected; and the conclusion was inevitable, that the cysts and their contents were sporangia of the species with which they were associated, and indicated the several stages of the reproductive process."

Again, in a gathering of *Synedra radians*, although not found at the time in a congregating state, yet the appearance of the cysts and of their contents was equally characteristic of the reproductive process. That such a "cystoid condition is one stage in the normal development of its reproduction," a subsequent examination in a distant locality satisfied him.

The prosecution of this inquiry into the final changes of the sporangial frustules is seriously impeded by the dissolution of the investing mucus and the consequent dispersion of the reproductive bodies.

Thirty-two species of the Diatomeæ have been observed in the act of conjugation, belonging to the genera *Epithemia*, *Cocconeis*, *Cocconema*, *Cymbella*, *Cyclotella*, *Gomphonema*, *Himantidium*, *Achnanthes*, *Rhabdonema*, *Melosira*, *Navicula*, *Surirella*, *Amphora*, *Orthosira*, *Encyonema*, *Colletonema*, and *Schizonema*. On this paucity compared with the number of known genera, Prof. Smith has the following explanatory remarks (*Synops*. ii. p. xi):—"One reason for the paucity of observations on this process in the Diatomeæ is no doubt to be found in the changes which usually take place in the condition of these organisms at this period of their existence. During conjugation the progress of self-division is arrested, the general mucous envelope or stratum produced during self-division is dissolved, and the conjugating pairs of frustules become detached from the original mass; they are thus more readily borne away and dispersed by the surrounding currents or the movements of worms and insects, and their detection becomes in consequence more casual and difficult. By far the greater number of the species I have mentioned belong to those genera whose frustules are adherent, or attached by stipes to foreign bodies, or which form continuous filaments or aggregated frondose expansions. Not more than four, viz. *Cyclotella Kützingiana*, *Navicula firma*, *Amphora ovalis*, and *Cymbella Pediculus*, are to be regarded as free forms: the reason I have just given will account for this circumstance; and the larger proportion of adherent or frondose species detected in conjugation may doubtless be ascribed to the firmer position conferred upon such forms by the presence of these accessory methods of attachment and adhesion, while the filamentous species, being usually aggregated in considerable masses or entangled amidst the branches of the larger Algæ, are also less liable to dispersion."

Another mode of development, first pointed out by Mr. Ralfs in his early contributions to the history of the Diatomeæ (*A. N. H.* 1843), by an internal gemmation or production of cells approaching in physiological features to self-division, appears to prevail in at least some instances. It is alluded to by Prof. Smith, when speaking of the *Meridion circulare* (*op. cit.* 7). He met with a variety of frustules, which upon a close examination, especially in a living state, led him to the conviction "that the appearance of a double wall of silex is owing to the formation within the original frustule of a second perfect cell, instead of the usual mode of division by which the original frustule is divided into two half-new cells.... In the present case, the central vesicle or cytoblast becomes enlarged without division, and secretes on its extension two new valves, which are pushed outwards until they lie in close approximation with the original valves. This process is not always repeated; the usual mode of self-division again recurs, and two valves are formed in the interior of this new cell according to the normal method....This unusual method of development is not, however, sufficiently constant to warrant the separation of such frustules from the species in which it occurs, perhaps hardly sufficient to constitute a variety, as frustules in both the ordinary and abnormal states may be met with in the same gathering and even in the same filament."

Himantidium Soleirolii is another species producing internal cells, which Prof. Smith quoted, remarking that he had no doubt it is merely an accidental modification of cell-growth, since, in the same filament, cells thus formed may be frequently found along with others following the normal mode of self-division. In *Odontidium anomalum*, this variety is in fact the usual condition of the frustules, and the ordinary mode of self-division is but rarely to be met with. A remarkable instance of this abnormal development presented itself to Prof. Smith in *Achnanthes subsessilis*, in which "the formation of a cell interior to the original one had proceeded through several successive stages, and the result is a compound frustule, consisting of the mother-cell and a number of included cells, each successive development being embraced by the others previously formed."

Mr. Ralfs has recently (*J. M. S.* 1857, p. 14) recurred to the subject of this plan of reproduction, and has found himself obliged to differ from Prof. Smith in some particulars. He writes: "Although it is true that 'we frequently find in the same filament cells thus formed, and others following the normal mode of growth,' as I formerly showed, yet I cannot agree to Prof. Smith's statement under *Himantidium Soleirolii*, that 'there is no doubt of its being merely an accidental modification of cell-growth.' On the contrary, I believe it to be a reproductive state of the species, and consequently to have a definite and important part in their economy.

"For several years I have attentively watched the circumstances connected with the formation of these inner cells in *Himantidium undulatum*, by gathering specimens at short intervals. During great part of the winter, the filaments increase in bulk, by repeated division of the frustules, until they form large masses, filling the ditches; at length the inner cells make their appearance, at first sparingly; but as spring advances, it is difficult, in many situations, to obtain a filament without them. I have found that when these become abundant, the filaments cease to grow, and the entire mass soon breaks up and disappears. The same thing happens in the other species of *Himantidium*, and in *Meridion*.

" I do not find that the inner cell commences in the centre and pushes its valves outwards, as stated by Prof. Smith. Were this the case, the internal matter also would necessarily be pushed outwards by the advancing valves, and thus condensed between them and the walls of the frustule. On the contrary, in the *Himantidium* the internal matter, before nearly fluid, collects within the new cell, becomes dense and more granular, and the new walls are formed round it in the situation they are to occupy, leaving an empty space between them and the walls of the frustule.

" The alteration and condensation of the colouring matter, and the appearance, or at least great increase of vesicles, have a strong resemblance to what takes place previous to the formation of sporangia, the completion of which, as in this case, usually preludes the death and disappearance of the mass.

" As in most acknowledged sporangia, the cell thus formed always tends to assume an oval or orbicular form. It, however, is very frequently, and perhaps generally, divided in halves, as in the fission of the frustules, so that the oval seems made up of two neighbouring frustules; but this is not the case, as may readily be ascertained by noticing the marginal puncta of the original frustule.

" Do these newly-constituted cells ever continue to divide, as Prof. Smith supposes? I believe not; at least I have never seen a specimen in which the semi-elliptic portions were separated by the interposition of other valves resembling either themselves or those of the ordinary frustule. For my own part, I have been unable to trace the species after the formation of these cells, owing to the quickly succeeding disappearance of the mass. If, indeed, this renewed division does occur, the resemblance to what takes place in the sporangia of some species of *Melosira* would be increased.

" Prof. Smith, in his most interesting and valuable account of the 'Reproduction in the Diatomaceæ,' enumerates four modes in which sporangia are formed. The third is thus defined:—

" 'The valves of a single frustule separate; the contents, set free, rapidly increase in bulk, and finally become condensed into a single sporangium.'

" As far as regards the *Melosira varians*, the only one in this group which I have had an opportunity of noticing, I believe the process is essentially the same as in the examples already described. The only difference is, that the new-formed cell being inflated, and much larger than the original frustule, the valves of the frustule must necessarily be either ruptured or pushed apart by the increasing growth of the sporangium, and the latter alternative happens.

" I have seen no specimen of Mr. Brightwell's *Chætoceros Wighamii*, but from his figures I believe the goniothecia-like bodies constitute another example of the formation of internal cells.

" I have said that I consider these internal cells sporangia, and essentially of the same nature as the inflated ones of *Melosira varians*. At the same time we should not forget that Mr. Thwaites discovered the *Himantidium pectinale* in a truly conjugated state, and that it is contrary to our experience of the economy of nature that the same result should be obtained in the same species in two different ways."

M. Focke has satisfied himself of the reproduction of some species of *Naviculæ* (*A. N. H.* 1855, 237) by a strange complication of the phenomena of "alternation of generation" and conjugation. *Navicula bifrons*, for example, forms, he says, by the spontaneous fission of its internal substance, spherical bodies which, like gemmules, give rise to *Surirella microcora*. These by conjugation produce *N. splendida*, which gives rise to *N. bifrons* by the same process. This last act of gemmation has been observed by the author in all its phases. He saw two specimens of *N. splendida*, enveloped in a sort of mucosity, open and evacuate the whole of their contents, which served to form a *N. bifrons*. The production of the reproductive bodies by the latter was also observed; but their development into *Surirella microcora*, and the production of *N. splendida* by conjugation, rest solely on the inductions of the author.

These facts require revision and confirmation, but they are, nevertheless, worthy of the attention of observers, and appear to point to phenomena quite as singular as those which have been revealed to us within the last few years by the study of the reproduction of so many of the lower animals. They, in fact, present in a manner the converse of the phenomena exhibited in the ordinary alternation of generation, as several germs or eggs are necessary for the production of the last individual of the cycle.

Kützing has surmised the existence of another mode of development, viz. by germs or spores prepared from the gonimic contents of the frustules. This method of propagation was indeed comprehended in Ehrenberg's doctrine that much of the granular contents were ova; an hypothesis started rather to bring the structure of the Diatomeæ in accordance with the generally assumed polygastric organization, than to explain any observed phenomena, complicated as it also was with other suppositions of fecundating male glands or seminal vesicles and a sexual discharging orifice.

Rabenhorst (*Süsswasser-Diatom.* p. 3) has followed up Kützing's suggestion, and affirms that the frustules of Diatomeæ swell up in a vesicular manner and become filled with a greater or less number of cells, which at first have an irregular figure, but subsequently assume a regular oval shape. This having happened, the cells move in a current from right to left within the cavity of the parent-cell, which by-and-by splits open and emits its progeny, each of which has, at an anterior clear space, two long projecting cilia. For a very short time these germs enjoy a swarming movement, and afterwards, on becoming stationary, attain with extreme rapidity, or even surpass, the size of the parent-cell, which is itself destroyed in the act. This plan of reproduction by the development of a brood of young organisms within a parent-cell, or, in more technical terms, this formation of active gonidia (microgonidia), prevails in many of the lower Algæ, and consequently has no *à-priori* argument against it. However, as Prof. Smith remarks, "Its occurrence in the Diatomeæ cannot be received as established without further observation and a more careful record of the phenomena attending its progress" (*op. cit.* vol. ii. p. xvii).

Rabenhorst has illustrated this mode of development in only one species of *Melosira*, although he puts it forward in a general manner as if true of all the Diatomeæ. Indeed it occurs to us that it is not a special and otherwise unobserved process of reproduction, but merely that variety of the act of conjugation described by Mr. Thwaites in the genus *Melosira*, in which a change in the endochrome of a single frustule, attended by an increase of contents and a consequent enlargement—such as is intimated in Rabenhorst's account—

converts it into a sporangium. Beyond this stage, Mr. Thwaites does not appear to have followed the sporangial frustule so generated; but, assuming the correctness of Prof. Smith's hypothesis of the generation and subsequent evolution of numerous minute frustules within it, do we not find a precisely analogous phenomenon with that which Rabenhorst represents as an additional mode of propagation, or with what Focke (see preceding page) describes as the formation of gemmules out of the internal substance, and their subsequent discharge? The supplementary phenomenon of alternation with change of specific form, included in the statement of the latter observer, even if confirmed, will not affect the general analogy presumed.

HABITATS.—*Appearance in masses, abundance, geographical distribution.—Fossil Diatomeæ.—Existence in the atmosphere.—Practical uses and applications of the Diatomeæ.*—The habitats and the distribution of the Diatomeæ, both in time and space, are the most extensive, various, and wide, of all organic beings. In fresh, in salt, and in brackish waters they are alike found; they exist abundantly in a living state about the roots of plants and diffused in moist earth; they are also to be met with in the dust of the atmosphere and in meteoric products. They are, in fine, inhabitants of earth, air, and water. When no longer alive, their silicious skeletons preserve their form and constant characters, uninjured by most of the causes which obliterate the remains of other living beings. They are so preserved in most of the rocks above the oldest primary—in all, indeed, in which intense heat has not operated to fuse silica into a molten mass. At the present day they are ejected from the bowels of the earth in the lava, cinders, and ashes of volcanos, and are borne about by the winds from one continent to another in showers of dust.

In respect of habitat, the Diatomeæ are divisible into marine and freshwater species; some indeed are common to both fresh and salt water, or exist in brackish water. The following account of the habitats of Diatomeæ, illustrated by reference to particular examples, is from the experienced pen of Mr. Ralfs, who has supplied us with it:—

"The Diatomeæ may be obtained at all seasons of the year, but are most plentiful in spring and summer, many of them indeed being limited to that period; thus the species of *Micromega* and *Schizonema* are, with few exceptions, in perfection only in May and June, when they are met with in sheltered situations, forming wide patches on the ground and on the flat surfaces of rocks exposed at ebb-tide. About the end of May the *Enteromorpha compressa*, so common on our shores, often seems as if faded at the end; this appearance is frequently accompanied by the presence of *Grammonema Jurgensii*, which is easily recognized by its slippery feel, when from its pale colour it would otherwise escape detection.

"At all seasons of the year, the smaller and more slender Algæ, marine and freshwater, as soon as they attain maturity, become almost invariably covered with parasitic Diatomeæ, which impart to them a brownish colour. In this way we obtain species of *Cocconeis, Achnanthes, Striatella, Tabellaria, Grammatophora, Isthmia, Gomphonema, Podosphenia, Rhipidophora*, and *Synedra*. On the contrary, *Amphitetras* and *Biddulphia* prefer the muddy crevices in the sheltered sides of perpendicular rocks.

"In salt marshes we may expect to find the *Achnanthes subsessilis* on the slender filaments of *Enteromorpha*, but so sparingly as hardly to discolour them. The species of *Epithemia* are parasitic on *Cladophora*, both in brackish and in freshwater pools. The *Melosiræ* are common in marshes, especially at the mouths of large rivers, where they form Conferva-like brownish masses.

"Many of the unattached Diatomeæ are produced in dark brown patches at the bottom of pools, or on the surface of mud; the freshwater species often by the road-side; the marine forms usually near high-water mark. *Amphipleura inflexa* and *A. scalaris* congregate, in large brown stains or spots, on the muddy sides of rocks, whilst other species, for instance *Campylodiscus*, and *Coscinodiscus concinnus*, form similar collections, but prefer more shady situations.

"The sides of ditches in brackish marshes are very prolific, especially after spring-tides, and in situations not again covered until the next high-tides. We may expect to gather in such places species of *Surirella, Navicula, Pleurosigma, Ceratoneis, Amphiprora, Amphora*, &c. The soil about the roots of rushes and of other plants inhabiting salt marshes often afford interesting forms, but seldom in abundance. We find there species of *Coscinodiscus* and of *Zygoceros*; but such are obtained more abundantly from the mud or from the washings of bivalve shells brought up from deep water or collected at the mouths of rivers. Oyster-beds are in general productive. The *Bacillaria paradoxa* inhabits ditches in which the water is nearly fresh, and is frequently obtainable from the scum driven from the surface to the banks.

"Few Diatomeæ are peculiarly autumnal; we have, however, gathered *Homœocladia Martiana, Berkeleya fragilis, Dickieia pinnata*, and *Striatella unipunctata*, chiefly at that season.

"On warm summer days, Diatomeæ, with various microscopic Algæ and Fungi, rise to the surface of water by the disengaged oxygen gas still adhering to them and buoying them up, and there form a delicate film or a scum, and at times even a layer of considerable thickness. Such collections are rich in species of *Navicula, Cymbella, Surirella*, and *Synedra*. When an entangled larger mass is formed, there is usually one prevailing species. Specimens of *Fragilaria* are generally found on decaying wood or leaves, or amongst Confervæ diffused in the water. From the drainings of *Sphagnum* may often be obtained *Synedra biceps* and various species of *Himantidium*. Boggy soil, especially when situated on a slope, affords various species of *Epithemia* and *Navicula*; so likewise does the soft matter on rocks on which water constantly trickles. Washings from oysters and the refuse raised by trawlers are usually rich in spheres of *Coscinodiscus, Actinoptychus, Pleurosigma, Diploneis, Navicula, Dictyocha*, &c. The same kind of washings from sheltered harbours give *Surirella fastuosa, Auliscus sculptus*, together with species of *Campylodiscus, Triceratium*, &c. Washings of corallines are likewise sometimes productive."

Mr. Norman supplies us with the following hints:—"The most interesting forms occur in salt water, especially in shallow lagoons, saltwater marshes, estuaries of rivers, pools left by the tide, &c. Their presence in any abundance is shown by the colour they impart to the aquatic plants they are attached to; or when found on mud, by the yellowish-brown film they form on the surface, and which, if removed with a spoon without disturbing the mud, will be found a very pure deposit.

"Such collections are best put at once in bottles, or even partially dried and wrapped in pieces of paper or tin-foil. When placed in bottles, a few drops of spirit are advantageously added. In all cases it is essential that the locality whence obtained should be plainly written on each package. Capital gatherings are obtainable by carefully scraping the brownish-coloured layer from mooring-posts, or the piles of wharfs or jetties.

"In clear running ditches, the plants and stones have often long streamers of yellowish-brown slimy matters adhering to them, generally composed almost wholly of filamentary species. The layers of Diatomaceous fronds on the surface of mud are often covered with bead-like bubbles of oxygen, which from time to time rises to the surface of the water and carries up with it some of the deposit in the form of a scum, which gets blown to leeward, and may be readily collected from the edge of the pond quite free from particles of mud and other impurities.

"Good and rare specimens have been obtained from the stomachs of Holothuridæ and other Mollusca which inhabit deep water, and are often thrown on shore after severe gales of wind. These animals may be merely dried and preserved just as found, and the contents of the stomach obtained afterwards by dissection. Shells and stones, covered with seaweed, &c., from deep water, also afford most interesting and little-known forms. The rougher these are, the better (they ought by no means to be cleaned). Deep-sea soundings (especially those from great depths) should be preserved; for they are often exclusively Diatomaceous.

"Very rare species have often been formed in immense quantities in the arctic and antarctic regions by melting the 'pancake ice,' rendered brownish by these microscopic shells. The sea is also often observed discoloured with brownish patches, which should be collected, and the water filtered through blotting-paper or cotton wool: the residuum will frequently turn out to be composed of Diatomeæ. It is also highly interesting to collect and examine the impalpable dust which occasionally falls into the folds of the sails of ships at sea."

Scallops and other Mollusca often contain rich and rare collections in their stomachs. In Ascidia (e. g. *Phallusia sulcata, Ascidia mentula*) Mr. Norman and the Rev. R. Cresswell found an abundant source. Mr. Norman adds, in a further note kindly sent us—"The Ascidians, whose stomachs are almost always so loaded with Diatomaceous frustules, are to be found abundantly on the shells of oysters dredged in deep water, and readily procurable from the trawlers.

"The *Salpæ* (found so abundantly floating on the surface of the sea in warm latitudes) afford very pure gatherings. The roots of the various species of mangrove, growing in the dense swamps of rivers and estuaries in the tropical regions of Africa, Australia, and the Eastern Archipelago, are said to be frequently covered with a brownish mucous slime very rich in Diatomeæ. I have also obtained very pure gatherings from the roots of the Dutch rushes, as imported, and from the *Zostera marina* from the Baltic, used for stuffing beds, &c., by upholsterers. Stones, moreover, brought as ballast from abroad, will amply pay the diligent collector by yielding foreign and perhaps rare species. The roots of aquatic plants from tropical countries, stored in herbaria, would, if properly examined, yield many interesting forms of Diatoms."

Indeed we may add, generally, that the roots of land plants, particularly of mosses, lichens, &c., growing around trees on the ground, or upon them, are fruitful in Diatomeæ, and, in fact, of some of the rarer forms. In the Number of the *Microscopical Transactions* just published (July 1858, p. 79), Col. Baddeley notes the occurrence of Diatoms in considerable numbers in the *Noctiluca miliaris*. They are the chief constituents of a mass of dark matter near the nucleus, and lie in the so-called vacuoles, into which they enter from the mouth. This occurrence suggests an easy method of obtaining different marine species of Diatomeæ in their natural state, often alive, and with their endochrome perfect. The Colonel discovered in this way several rarer species, and gives a list of nearly 50 which he identified, besides not a few forms of whose true name he was uncertain. To extract the Diatomaceous mass from the interior of the *Noctilucæ*, Col. Baddeley recommends that the seawater and its living freight be poured, on arriving home, in a white hand-basin, and be let stand for an hour or two. "This rough treatment causes these creatures to disgorge their food; and if, after an interval, the water be carefully poured off, a sediment will be found at the bottom, which will consist of Diatoms mixed with some refuse."

Dr. Donkin lately (*T. M. S.* 1858, p. 11) called attention to the occurrence of that rare form, *Syndendrium diadema,* in the stomach of the lobster, and in a subsequent paper (*op. cit.* p. 14) alludes to the abundant deposit of living Diatoms upon the sands at the sea-side, in the following paragraph:—"Professor Smith states that 'the shallow pools left by the retiring tide at the mouths of our larger rivers' are the favourite habitat of marine species. But such localities I have found not to be half so prolific in species as the *sands of still bays, on the shore, where they are exposed by the reflux of the tide, at a distance corresponding with the half-tide margin.* In these places, where the sands are sloping towards the sea, and grooved out into small furrows, filled with salt water oozing out from behind, the abundance of Diatoms aggregated into a living mass imparts to the surface of the sand different hues of chestnut and olive, the difference of colour being due to the nature of the species present. These coloured patches, it is interesting to observe, are, during the sunshine, studded with numerous minute air-bubbles, undoubtedly given off by the Diatoms themselves.

"To separate the Diatoms thus detected, from the surface of the sand, I found to be impossible. I therefore seized hold of the nearest bivalve shell which happened to lie in the way, and with this I carefully scooped up the surface of the coloured sand. This I emptied into a wide-mouthed, stoppered bottle, capable of holding eight ounces, until half full; the other half of the bottle I filled up with salt water. I then shook the whole briskly and allowed the bottle to stand for a short period. The sand, being composed entirely of fine round grains of quartz and the minute fragments of shells, settled at the bottom in a few seconds, leaving the Diatoms all suspended in the water above, and forming by their abundance a chestnut-coloured cloud, but not more than 1 part in 1000 of the whole sand collected. The coloured water was then poured into another bottle, and formed the gathering, while the sand was thrown away. The Diatoms, in their turn, were separated from the superfluous water by subsidence, and brought home in 1½-oz. bottles. In this manner I soon found that any quantity could be collected in a pure and unmixed condition, affording an excellent opportunity of examining their living forms, and one of which I availed myself on every occasion.

"After carefully examining materials collected in this way from various parts of the beach, I detected not less than about 100 species, all these strictly marine, and, with a few exceptions, each species in considerable abundance."

The fact of Diatomeæ rendering themselves perceptible to common vision by their excessive accumulation and the colour they impart to water, is illustrated by the phenomenon of coloration of the sea recorded by Dr. Hooker, also by the *Melosira ochracea,* which occurs in many, perhaps in all, chalybeate waters, and also in peat water containing a small proportion of iron. It is of the colour of iron rust, and in mineral springs, in which it abounds, is often taken for precipitated oxide of iron. It covers everything under water, but forms so delicate and floccose a mass that the least motion dissipates it. In the spring of the year this mass is composed of very delicate, pale-yellow globules, which can be easily separated from each other. They unite together in rows like short chains, and produce an irregular gelatinous felt or floccose substance. About summer, or in autumn, they become developed into more evidently articulated and stiff threads of a somewhat larger diameter, but still form a complicated mass or web, and, either from adhering to each other or to delicate Confervæ, appear branched. In the young condition, when examined under shallow magnifiers, they resemble gelatine; but with a power of 300 diameters the flexible granules are discoverable, and, with dextrous management, the little chains forming the felt or floccose web can be made out. In summer, on the other hand, its structure can be observed much more easily and distinctly. Early in spring the colour is that of a pale yellow ochre, but in summer that of an intense rusty red. Other examples occur where a single species becomes tangible to the unaided senses; such are met with in the brown specks mentioned in the preceding account of habitats formed by particular species upon the larger Algæ and Confervæ. So the *Gomphonema geminatum* forms on rocks tufts of a spongy texture and brownish colour when young, but white afterwards. The *Synedra Ulna* often produces a white incrustation on stones in rivers in summer; and *Fragilaria* and *Odontidium* are seen outstretched as delicate brown filaments, several feet in length, like many filiform Algæ, from which, however, they differ by breaking up so very readily, on the least disturbing force, into their separate joints. "Large numbers of *Rhizoselenia*" (writes Mr. Brightwell, *J. M. S.* 1858, p. 95) "have been detected in the stomachs of *Salpæ*, and they have also been observed floating free in the ocean in warm latitudes, their appearance being that of little confervoid flakes of exquisite delicacy, but of a sufficient aggregation of filaments to be seen by the naked eye. The mass appeared (probably from the endochrome) of a faint, evanescent, ochraceous colour." Moreover, the frondose species generally attain an appreciable magnitude. Thus *Encyonema prostratum* forms a tuft-like stratum,—when recent, dark brown, but when dried, of a dull green colour. *Schizonema subcohærens* grows into tufts from a quarter to half an inch or more high; and *S. vulgare* constitutes a dark brown gelatinous stratum on stones in shallow water, filaments simple or nearly so in deep still water, and much branched filaments in deep rapid streams.

Mr. Norman, of Hull, has most kindly furnished us with the following original observation on the growth of one species, the *Campylodiscus costatus*:—"In the early part of the spring of 1856," he writes, "I made a gathering of freshwater Diatomeæ from the 'Spring Ditch,' Hull. Although I met with a few odd frustules of the species named, I did not consider it of sufficient interest to boil in acid for mounting, and the phial containing them was left in the window of my laboratory during the ensuing summer. Some time in the autumn I had occasion to make use of this bottle, and was on the point of throwing away the contents, when I noticed the surface of the deposit and the sides of the bottle to be covered with a dense brown growth of Diatoms. On further examination I found an immense colony of *Campylodiscus*, which gave by preparation some beautifully pure slides of this species. In removing the upper layer I purposely left a few of the frustules in the bottle, which was again placed in the window. These have again increased to a great extent, and now (December 1857) they appear to thrive in perfect health. Does not this occurrence suggest an easy plan of procuring in a pure state such forms as are rarely found together in any abundance?"

Geographical Distribution.—Species of Diatomeæ are for the most part distributed over a very wide geographical area. Some, indeed, would seem cosmopolitan, whilst others are limited to certain regions. For instance, the *Terpsinoë* has not been discovered in Europe; and *Synedra Entomon* is reckoned by Ehrenberg as peculiarly a South American production. This author has given full force to this seeming fact, and employed it in the endeavour to discover the origin and course of meteoric dust, and also to arrive at certain geological deductions. For example, he says (*Monatsb. Berlin.*

Akad. 1849), "The chain of rocky mountains traversing the continent of North America, forms, with reference to the distribution of Infusoria, a stronger barrier between California and Oregon, and the rest of the continent, than does the Pacific Ocean, with China, between the western plains of North America and the region of Siberia. Thus, the United States, with Mexico, never present any of the forms characteristic of Oregon and California, whilst, on the other hand, the peculiar forms of these latter countries are met with in Siberia. All this is remarkably confirmed in this, that the gold region of the Sacramento, in the extent and abundance of its Infusorial products, finds its parallel only in Siberia."

This presumed fact of limited geographical distribution is thus applied by Ehrenberg in another paper (*Monatsb.* 1846):—"The atmospheric dust which, since 1830, has fallen in the Atlantic Ocean as far as 800 miles west from Africa, on the Cape de Verde Islands, and even in Malta and Genoa, has been all of an ochre-yellow colour, never grey like the dust seen in the north of Africa, and consists of from $\frac{1}{8}$th to $\frac{1}{3}$rd of organic particles referable to 90 species, the greater number of which are of freshwater habit, and found equally in the most widely separated regions named. This dust, even in Genoa, whence it is carried by the Sirocco wind, contains no characteristic African forms, but, on the contrary, presents the *Synedra Entomon*, a decidedly characteristic species of South America." From his observations on this meteoric dust, Ehrenberg concludes that there is a current of air uniting Africa and America in the region of the trade winds, and occasionally directed towards Europe. On the other hand, their wide diffusion is exemplified in Dr. Hooker's Report on the Diatomaceous vegetation of the Antarctic sea (*Brit. Assoc.* 1847):—"The genera and species of Diatomaceæ collected within the Antarctic sea are not at all peculiar to those latitudes; on the contrary, some occur in every country between Spitzbergen and Victoria Land. Others, and even some of these, have been recognized by Ehrenberg as occurring fossil in both Americas, in the south of Europe and north of Africa, in Tripoli stone and in volcanic ashes ejected both from active and extinct volcanos, whilst others again exist in the atmosphere overhanging the tropical Atlantic."

Prof. Smith has the following remarks on cosmopolitan or very widely-diffused species (*Synops.* ii. p. xxvii):—

"Of freshwater species frequent in the British Islands, the following seem almost cosmopolitan, viz. *Synedra radians*, *Pinnularia viridis*, *Pinnularia borealis*, and *Cocconema lanceolatum*. Gatherings from many localities in Europe, from Smyrna and Ceylon, from the Sandwich Islands, New Zealand, and New York, from the loftiest accessible points of the Himalaya in Asia, and the Andes in America, have supplied specimens of these forms.

"*Navicula serians* abound in all our mountain bogs, and is equally common in the marshes of Lapland and America.

"*Epithemia gibba* is an inhabitant of the Geysers of Iceland and the lakes of Switzerland.

"The South Sea Islands supply *Stauroneis acuta*, and Ceylon *Synedra Ulna*, while *Stauroneis Phœnicenteron* is equally abundant in Britain, Sicily, and Nova Scotia.

"These notes of localities will give some idea of the wide distribution of our fluviatile Diatomaceæ: more numerous gatherings would, no doubt, greatly extend the list; and the following circumstance will show how generally our commoner British forms are diffused throughout European localities that have been carefully examined. During a tour in Languedoc and the Auvergne in the spring of 1854, I made upwards of forty gatherings from the rivers, streams, and lakes of the district I traversed. In these I detected 130 species, and but one form not yet determined as indigenous to Britain. If this be the case with a district much of whose Phanerogamous flora is so different from our own, it bears out the view I have taken, that these organisms enjoy a range of distribution far more general than the higher orders of plant-life.

"Nor is the distribution of marine species less notable for its extent and uniformity. *Coscinodiscus eccentricus* and *C. radiatus* range from the shores of Britain to those of South Africa. *Grammatophora marina* and *G. macilenta* are found in almost every marine gathering from the Arctic Ocean to the Mauritius. *Stauroneis pulchella*, *Cocconeis Scutellum*, and *Biddulphia pulchella* are equally abundant on the European, the American, and the African coasts, while *Rhabdonema Adriaticum* belies its name by its occurrence in the Indian, Atlantic, and Pacific Oceans. During the researches already mentioned, in the South of France, I made several prolific gatherings on the shores of the Gulf of Lyons; but, of 33 forms occurring in these, *Hyalosira delicatula*, Kütz., was the only one not familiar to me as a British species."

The supposition that many species of Diatomeæ occupy a very limited geographical area, and that considerable numbers have, in course of ages, disappeared or become extinct, as many animal and vegetable organisms have done, was thus ably examined by the lamented Dr. Gregory in a communication to the Royal Society of Edinburgh, made in 1856 (*Proc. Roy. Soc. Edin.* 1856–57, p. 442). The subject of discussion is introduced in his notice of *Navicula prætexta*, a form previously considered only fossil. "I have," he says, "selected this form because the bed in which it occurs fossil is the oldest in which Ehrenberg has found any Diatoms. He has indeed found microscopic organisms in the chalk, and even in older rocks, among which he mentions the mountain limestone and the Silurian greensand. But the forms in the two latter rocks are not numerous, and, as well as those which abound in the chalk, belong to the Foraminifera or to the Polycystina, not to the Diatomacea.... In short, I have no hesitation in saying, that I believe all the forms in the Ægina clay-marl, which is the oldest Diatomaceous deposit yet described, will be found living on our coast." The stratum at Ægina belongs either to the chalk formation, or to the oldest tertiary or Eocene beds.

Dr. Gregory continues, "It may also be observed that, of all the forms figured by Ehrenberg from more recent strata, whether miocene, like the bed on which the town of Richmond (Virginia) is built, and several kinds of Berg-mehl—or pliocene, like other Berg-mehls or polishing-slates, &c.—or still more recent, the great majority are perfectly identical with existing Diatoms. Indeed, although many forms are stated in Ehrenberg's earliest writings to be fossil only, and have been supposed to be extinct, the progress of observation is continually adding to the number of species which are found also in the recent state. Thus, for example, the whole group of dentate *Eunotiæ*, which abound in the Lapland and Finland Berg-mehls, were long thought to be only fossil; but they have been nearly all found in America, and I have myself seen several of them recent in this country. *Eunotia triodon*, long supposed to be extinct, occurred scattered in many of the Scottish freshwater gatherings.

"Taking these facts into consideration, I am led to believe that we have no evidence that any species of Diatom has become extinct, as so many species, and even genera and tribes, of more highly organized beings have done. I observe that Mr. Brightwell expresses a similar opinion in his valuable paper on *Chætoceros* (*J. M. S.* iv. p. 105)."

Wherefore Dr. Gregory comes to the conclusion, that "the whole of the species which occur fossil will, ere long, be detected in the recent state. It is at all events certain that a very large proportion of the Diatoms found in the fossil state also occur in the living state, and that every day adds to their number. There is at present no good evidence of the existence of Diatoms earlier than the chalk, if so early. But we must not forget that the shells of Diatoms appear to be altered by long contact with carbonate of lime, so that they may have existed at one time in the chalk. We find them, however, in spite of the action of calcareous matter, in the recent chalk-marls of Meudon and of Caltanisetta, which are rather more recent than the chalk, and probably of about the age of the clay-marl of Ægina. If, as I believe, no Diatoms have become extinct, this may perhaps depend on their minute size and extreme simplicity of structure, which probably render them more indifferent to climatic changes than more highly organized and larger beings. We have evidence, to a certain extent, that this is the case; for by Ehrenberg's figures it appears that, in gatherings of recent Diatoms from all parts of the world, in every possible variety of climate, the majority of species are identical with our own.

"Diatoms, therefore, are not materially affected by existing differences of climate, and have probably been as little affected by the geological changes which have occurred, at all events, since the period of the Eocene deposits."

GEOLOGICAL IMPORTANCE OF DIATOMEÆ.—FOSSIL ACCUMULATIONS.—Although so exceedingly minute and apparently insignificant in comparison with the animals and plants usually claiming our notice, yet, by their excessive multiplication and accumulation, they assume even a greater importance, in the physical history of the earth, than the largest trees or animals with which we are acquainted. This lesson is taught us by living examples of these microscopic beings constituting appreciable masses, and by innumerable instances where only the silicious skeletons remain, in a fossil or semi-fossil condition.

Ehrenberg thus illustrates their rapidity of production and accumulation. "Silicious Infusoria," he says, "form, in stagnant waters during hot weather, a porous layer of the thickness of the hand. Although more than 100,000,000 weigh hardly a grain, one may in the course of half-an-hour collect a pound weight of them; hence it will no longer seem impossible that they may build up rocks. However, one of the most striking examples of the operation of Diatomeæ as a physical agency on a large scale, is afforded by Dr. Hooker's observations addressed to the British Association (*Report*, 1847). He says—"The waters, and especially the newly-formed ice of the whole Antarctic Ocean, between the parallels of 60° and 80° south, abound in Diatomaceæ,—so numerous as to stain the sea everywhere of a pale ochreous brown, the surface having that colour as far as the eye can reach from the ship. Though peculiarly abundant in the Icy Sea, these plants are probably uniformly dispersed over the whole ocean, but, being invisible from their minuteness, can only be recognized when washed together in masses, and contrasted with some opake substance. They were invariably found in the stomachs of Salpæ and of other sea animals, in all latitudes between that of the tropic and the highest parallel attained in the Antarctic expedition. Their death and decomposition produce a submarine deposit or bank of vast dimensions, consisting mainly of their silicious shields, intermixed with Infusoria and inorganic matter. Its position is from the 76th to the 78th degree of south latitude, and occupies an area 400 miles long by 120 wide. The lead sometimes sank two feet in this pasty deposit, and on examination showed the bottom made up in great measure of the species now living on the surface. This deposit may be considered as resting upon the shores of Victoria Land and of the Barriers, and hence on the submarine flanks of Mount Erebus, an active volcano 12,000 feet high. From the fact that Diatomeæ and other organisms enter into the formation of pumice and ashes of other volcanos, it is perhaps not unreasonable to conjecture that the subterranean and subaqueous forces, which keep Mount Erebus in activity, may open a direct communication between this Diatomaceous deposit and its volcanic fires. Moreover, this bank flanks the whole length of Victoria Barrier, a glacier of ice 400 miles long, whose seaward edge floats in the ocean, whilst its landward extends in one continuous sweep from the crater of Mount Erebus and other mountains of Victoria Land to the sea. The progressive motion of such a glacier, and accumulation of snow on its surface, must result in its interference with the deposit in question, which, if ever raised above the surface of the ocean, would present a stratified bed of rock which had been subjected to the most violent disturbances."

But instances of the abundance of silicious organisms in sea- or river-bottoms are to be met with nearer home. Mr. Roper has explored the mud of the Thames (*J. M. S.* 1854, p. 68); and he tells us that, excluding the coarse sand, nearly one-fourth of the finer part of the residuum is entirely composed of the silicious valves of different species of Diatomeæ,—"marine forms prevailing." This writer also quotes the experience of Ehrenberg, who, with respect to the mud of the Elbe, has established the remarkable fact that at Gluckstadt, a distance of 40 miles, and even above Hamburg, upwards of 80 miles above the mouth of the river, marine silicious-shelled Infusoria were found alive, and their skeletons deposited in it in such abundance, that at the former locality they form from one-quarter to one-third of the entire mass, and that the proportion is still about one-half that amount at Hamburg, as far as the flood-tide extends. All his observations gave a great predominance of marine over freshwater species, even when the salt taste of the water was no longer perceptible. His examination of the mud of the Scheldt and Ems furnished similar results, as did that of the marine deposit in various littoral regions of the North Sea and Baltic.

Reverting to the Thames deposit, Mr. Roper expresses his belief that the silicious shells "have a perceptible influence in the formation of shoals and mud-banks in the bed of the river. . . . And the great abundance and general distribution of species serve to illustrate the occurrence of similar deposits in a fossil state at localities now far removed, by alterations in the earth's surface, from the streams or harbours in which they were originally deposited.

"Another point worthy of attention is the influence of these organisms in the formation of deltas at the mouths of large and slowly-flowing rivers—such, for instance, as the Mississippi, in which the mean velocity of the current at New Orleans is only about one mile and a half per hour for the whole body of water. Sir Charles Lyell, from experiments on the proportion of sediment carried down by the river, has calculated that, taking the area of the delta at 13,600 square miles, and the quantity of solid matter brought down annually at 3,702,758,400 cubic feet, it must have taken 67,000 years for the whole delta. Now, as the silicious frustules of the Diatomeæ are secreted from the water alone, and would most probably be extremely abundant in so sluggish a stream (especially as Prof. Bailey has found both marine and freshwater species abundant in the rice-grounds), there can be little doubt that, without taking the larger proportion noticed by Ehrenberg in the Elbe, even if it were considerably less, it would reduce the above period by several thousand years; and the same cause would probably apply with equal force to the Ganges and Nile. Ehrenberg considered that, at Pillau, there are annually deposited from the water from 7200 to 14,000 cubic metres of fine microscopic organisms, which, in the course of a century, would give a deposit of from 720,000 to 1,400,000 cubic metres of infusory rock or Tripoli stone."

Another fact exemplifying the widely pervading presence of silicious Infusoria was revealed by the experiments of Ehrenberg, viz. their existence in a living state in moist earth beneath the surface, the only vital condition necessary being a small quantity of moisture. The presence of their remains at considerable depths in mud also is well exemplified by the experimental borings made by Mr. Okeden (*J. M. S.* 1854, p. 26) at Neyland, a creek of Milford Haven, where deposits rich in Diatomaceous remains of marine or brackish and freshwater character occurred at the depth of 20, 30, and 40 feet.

The preceding illustrations will suffice to show the active share taken by the Diatomeæ at the present day in the ever-occurring changes of the earth's surface; others must now be adduced to exemplify their influence in the past physical changes of the globe. These examples are so numerous, and, relative to other phenomena, so important, that it is embarrassing to make a selection. Ehrenberg is the most assiduous cultivator of this department of knowledge. He has personally examined deposits collected from almost every country of the world, and described, with illustrative plates, the genera and species he has encountered in them, in his recent large work the *Mikrogeologie*, 1855. One of the most striking and, to his mind, unique instances of a Diatomaceous deposit, formed at a remote or geological period, he has shown to exist in North America, on the banks of the Columbia River.

The river of Columbia, in its course at Place-du-Camp, runs between two precipices 700 to 800 feet high, composed of porcelain-clay 500 feet thick, covered over by a layer of compact basalt 100 feet thick, on which, again, some volcanic deposits exist. The clay strata are of very fine grain, and vary in colour; some are as white as chalk. Dr. Bailey has shown, from some portions submitted to him by Col. Fremont, that this apparently argillaceous layer is entirely composed of freshwater Infusoria. Its perfect purity from sand shows that it is not a drift, but has been formed on the spot. By its immense thickness of 500 feet, this layer of biolithic Tripoli far surpasses any similar layers elsewhere, which attain ordinarily only one or two feet thickness, although those of Luneburg and Bilin have a depth of 40 feet. Some beds we also know elsewhere having 70 feet; yet such are not pure, but intersected by strata of tufa or of other material.

A very pure Diatomaceous deposit has been met with by Dr. Gregory in the island of Mull, which when dry is almost white, and much resembles chalk, being light, pliable, and adherent to the fingers (*T. M. S.* 1853, p. 93), and in composition hardly contains anything besides silicious organic remains "for the most part entire, but with some fragments; other portions which are denser contain also many fragments of quartz of various sizes, and vast numbers of comminuted fragments of loricæ." Prof. Smith (*Synops.* vol. i. p. xii) says—"Districts recovered from the sea, in the present or other periods of the earth's history, frequently contain myriads of such exuviæ forming strata of considerable thickness." Examples of this nature in our own country are met with in "the ancient site of a mountain lake in the neighbourhood of Dolgelly, localities of a similar kind near Lough Island-Reavey in Down, and Lough Mourne in Antrim." Mr. Okeden concludes, from facts collected by borings in the mud of some creeks and rivers of South Wales, "that not the surface merely, but the whole mass of these tidal deposits is penetrated by these minute and wondrous organisms, while, from the fact of their being found at Neyland at a depth of 40 feet below the present surface, and close upon the rock which forms the original bed of this estuary, the mind is irresistibly led to the conclusion that they have existed there from the time when the waters first rolled over the spot."

Berg-mehl, Tripoli, and other polishing-powders, the stratified deposits at Bilin in Bohemia and in Ægina, and numerous others examined and reported on by various microscopists might likewise be adduced to demonstrate the important part played by these individually invisible beings, when accumulated in countless myriads, in the construction of the earth's crust.

The Oolitic, and even some earlier metamorphic rocks, porphyritic rocks, &c., are not wanting, according to Ehrenberg, in species of Diatomeæ; but in the Pliocene, Miocene, Eocene, and in chalk and flint, and still more in the tertiary deposits, the abundance and variety of forms are greater. Diatomaceous shells are curiously preserved to us in large abundance and perfection in guano, in which they have doubtless entered as a component in the way of mixture with food taken by the birds which have deposited that manure.

The foregoing facts teach us that probably, in the present condition of our planet, no portion of its surface is destitute of Infusorial life; and now, from the prosecution of microscopic research in connexion with geological facts, it would appear that, under this simplest and primary form, organic life made its first appearance on the globe, and has, during the many epochs of this world's history, and notwithstanding the mightiest changes its surface has undergone, been sustained until the present moment; and, what is more, so extraordinary is the capability of the silicious Diatomeæ to preserve life, and so astonishing their powers of multiplication, that species which are now found living have their generic and even their specific types at the very dawn of creation. Prof. Ehrenberg has advanced this same statement in his recent work (*Mikrogeologie*), saying that the oldest silicious Infusoria, whether Carboniferous or Silurian, belong to the same genera, and often to the same species.

Aërolitic Diatomeæ.—Ehrenberg was the first to demonstrate the frequent existence of Diatomeæ along with other microscopic beings and organic particles in the atmosphere, principally in those showers of dust which fall from time to time in various parts of the world, and in those other meteoric products known by the name of 'meteoric paper' and 'blood-rain.' In such atmospheric productions, the Berlin naturalist has detected above a hundred species; these, accompanied by descriptions and figures, and prefaced by an account of all such atmospheric phenomena on record, were published by Ehrenberg in a large brochure entitled "*Passatstaub und Blutregen*," consisting of 192 folio pages. An extract from this book will convey the best attainable notion of the physical importance of these aërial dust-showers.

The quantity of actual solid matter that has fallen from the atmosphere by showers is far more considerable than supposed; for, though it falls in a diffused dust-like form, the extent of surface covered at any one time is very considerable. Comparing it with meteorolites, Ehrenberg observes that the total quantity of these stones which fell between 1790 and 1819 weighed 600 cwt., while in a single dust-shower at Lyons, in 1846, the solid matter weighed fully 7200 cwt. Other dust-storms in Italy, at Cape de Verd, and in other localities have exceeded even that at Lyons, in the quantity of matter precipitated to the earth; and Ehrenberg suggests to the imagination the millions of tons that must have fallen since the time of Homer. Lastly, he entertains the curious opinion, that this meteoric dust does not necessarily derive its existence from the earth's surface, and from the force of atmospheric currents, but from some general law of the atmosphere, according to which the living organisms mainly composing it may have the power of self-development in the air.

USES OF DIATOMACEOUS DEPOSITS.—The utility and possible and probable purposes of these minute organisms to mankind have not yet met with due consideration. Their relation to the soil, in which they are so abundant, and their influence on its fruitfulness are matters only incidentally reflected on by authors. "Sufficient attention," remarks Prof. Gregory (*J. M. S.* 1855, p. 2), "has not yet been paid to the fact of the invariable presence of Diatomeæ in all earths in which plants are found. Ehrenberg, in his *Mikrogeologie*, has established the fact as a universal one, and pointed out the important bearing it has on the *growth of the soil.* Indeed, it is difficult to imagine a more effectual agent in the transference of silica from the waters to the solid earth than the growth of Diatomeæ, the shells of which are as indestructible as their multiplication is rapid. Ehrenberg is of opinion that they live in the soil as well as in water; and the constant presence of moisture in the soil renders this conceivable. Although the proportion of silicious matter dissolved in ordinary water is but small, it is evidently sufficient to supply the shells of millions of Diatoms in a very short time; and it is therefore probable that, as fast as it is extracted from the water by them, it is dissolved from the rocks or earths in contact with the water, so that the supply never fails."

Mr. Roper has also suggested, from the consideration that the best samples of guano contain the greatest number of these silicious skeletons, which doubtless serve to replace the large amount of silica abstracted from the soil by the cereal crops, that it is probable that the deposits of many of our rivers would have a beneficial effect if applied to the land; and it rests with the microscopist to point out the most favourable localities for obtaining them. Ehrenberg notices an instance where this has been done in Jutland, where a blue sand abounding in calcareous and silicious shells is collected, and greatly increases the fertility of the arable soil to which it is applied; and Prof. Bailey also states that the mud of Newhaven harbour is used as a fertilizer, and is found to contain 58·63 per cent. of silica. The author last-named has moreover adduced instances to prove that the great fertility of the rice-fields of South Carolina is mainly due to their richness in Diatomaceous remains. This notion is strengthened by the examinations of Ehrenberg, and by the commonly observed fact of the occurrence of Diatomeæ about the roots of plants, especially of the cereals, which demand a large supply of silicious material to construct their stems.

Dr. Hooker (*op. cit.*) contends that the abundant Diatomaceous deposits of the South Pole supply ultimately the means of existence to many of the smaller denizens of the ocean, and that they keep up that balance between the animal and the vegetable kingdom which prevails through all other latitudes. He adds that they probably purify the vitiated atmosphere, just as plants do in a more temperate region.

In the arts, the remains of Diatomaceous shells, as the chief ingredients in certain deposits, are brought into use as polishing-powder under the name of Tripoli, and also, as an extremely fine and pure silicious sand, in the manufacture of porcelain. The powder called Tripoli has various origins, and differs in the microscopic organisms it contains. Species of *Melosira* especially abound—for instance, of *Melosira varians.* Ehrenberg informs us that the Tripoli of Jastraba in Hungary and that from Cassel resemble each other in their component species.

A very remarkable application of a deposit of Diatomeæ is its use as an article of food, under the pressure of want, by the wretched inhabitants of some inhospitable and barren districts of Europe—for instance, in some localities of Lapland and of Hungary, and in other parts of the world. Ehrenberg mentions a sort of earth under the name of "Tanah," eaten in Samarang and Java, which overlays some mountains of Java at several places at a height of 4000 feet. It is generally solid, plastic, and sticky; it is rolled and dried in the shape of small sticks over a charcoal fire, and is eaten as a delicacy. An examination of this earth disclosed 3 or 4 species of Polygastrica and 13 of Phytolitharia.

It has been attempted to make the specific characters of Diatomaceous deposits of critical value in deciding on the date and superposition of rocks. However, the geographical distribution of these beings is as yet insufficiently known; and every day reveals the fact that species deemed peculiar to some one locality are to be found in others, and to have at least a very wide range. We have already quoted some examples of apparent limited diffusion in our remarks on geographical distribution; it is therefore not necessary to illustrate the subject further in this place.

The circumstance that some one or two species seem at times peculiar to a neighbourhood, has encouraged antiquarians to seize on it with the hope of determining the locality whence the clay was procured from which ancient specimens of pottery or porcelain were manufactured.

Another practical purpose to which the shells of Diatomeæ have been put is as test-objects for microscopes, the penetrating and defining powers of which are measured by their ability to detect and demonstrate the existence and nature of certain markings on the surface of the silicious epiderm—such, for example, as the striæ of *Pleurosigma*.

ON THE NATURE OF DIATOMEÆ, WHETHER ANIMALS OR PLANTS — VARIOUS HYPOTHESES.—The nature of the Diatomeæ is still a much-vexed question, although the opinion of those naturalists who hold them to be plants—members of the great family of Algæ—preponderates. Ehrenberg assumed their animal nature, and persuaded himself of the existence of a complicated organization, such as neither the researches of others can confirm nor analogy support. In his latest papers on Organization, he has insisted most strongly on the apparent successful feeding of these organisms with particles of colour which entered within their interior. These experiments are not satisfactory, and have failed in the hands of others; it is besides quite clear, that the umbilicus, at which he represented the colour-granules to enter, is no real opening in the lorica, but a thickening of its epiderm.

Prof. Meneghini, now many years ago, penned a learned treatise to prove the animality of the Diatomeæ; but although he offered many ingenious arguments to support his opinion, he did not succeed in establishing it. Many details of structure and organization and micro-chemical characters, urged by him in favour of their animal nature, have been considerably modified or entirely set aside by subsequent researches; and the general argument, that the variation from recognized plants is in many particulars very marked, has only a comparative or relative force, according to the extent of differential structure of animals which may, on the other hypothesis, be set forth and proved.

The distinguished Italian naturalist indeed limits his design in the treatise before us (On the Animal nature of the Diatomeæ, *R. S.* 1853) to disputing Kützing's arguments for their vegetable nature, saying (p. 365), "Whilst unable to confirm or refute the opinions of Ehrenberg, we seem to have observed facts sufficient to disprove those of Kützing."

On this same side are ranged Focke, Eckhardt (a pupil of Ehrenberg), and Prof. Bailey, who express their inability to reconcile some of the structural details and physiological phenomena with vegetable organization. Schleiden perhaps should also be reckoned of the number, since he remarks, in his description of the shield of a *Navicula*, that "such an artificial and complicated structure amongst plants has no explanation, and is entirely without signification. In all actual plants we find the silica present in quite a different form, as little separate scales or drops, and distributed through the substance of the cell-wall."

In favour of the vegetable nature of the Diatomeæ, on the other hand, the majority of the original observers in this country unite with many of the most distinguished naturalists of the Continent, such as Kützing, Siebold, Nägeli, Rabenhorst, Braun, Cohn, Meyen, &c. The last inquirer, so long ago as 1839, urged various objections against the presumed animality of the Desmidieæ and Diatomeæ, and more particularly against Ehrenberg's views. Respecting the animality of the Diatomeæ (Naviculacea), he remarks generally—"The reasons adduced for such belief are so weak, that the conclusions deduced from them are yet for the most part very doubtful."

A small number of naturalists have expressed the notion that the Diatomeæ belong equally to the animal and to the vegetable kingdom. M. Thuret may be named as one of these, since he has stated that there is no more reason in favour of the one affinity than of the other. Such an idea is certainly unphilosophical; for it would cut the knot instead of loosening it, by the assumption of an order of organic beings intermediate between the animal and the vegetable kingdom, and undeterminable to which they belong.

We will now proceed to state the leading arguments for the animality of the Diatomeæ, indicating the name of the writer suggesting each, so far as practicable:—

1. The Diatomeæ—many species at least—exhibit a peculiar *spontaneous* movement, which is produced by certain locomotive organs.—*Ehrenberg.*

2. The greater part have in the middle of the lateral surface an opening, about which certain round corpuscles are situate, which become coloured blue when placed in water containing indigo, like the 'stomach-cells' of many Infusoria, and consequently may equally be regarded as stomachs.—*Ehrenberg.*

3. The shells of many Diatomaceæ resemble in structure and conformation the calcareous shells of Gasteropoda and similar Mollusca.—*Ehrenberg.*

4. The method of multiplication by self-division.—*Ehrenberg* and *Meneghini.*

5. The complicated structure of the wall of the frustules, and the characters of the silicious deposit.—*Schleiden, Bailey,* and *Meneghini.*

6. The greater affinity in chemical composition of the contents (the endochrome) with animal than with vegetable products.—*Meneghini.*

Each of these arguments requires examination in detail, and its value tested. To begin therefore with the first—the occurrence of locomotion and the organs by which it is effected, as evidences of animal constitution. Morren, in the paper quoted (*Jahresbericht Akad. Berlin*, 1839), pointed out that motion is not confined to animals, but exhibited also by the spores of Algæ and by spermatic particles. To these examples may be added the Oscillatoriæ, *Protococcus* in its various phases, *Vaucheria clavata, Ulothrix zonata,* and other Algæ, among which are the now admitted genera of Volvocineæ. In many of these, the movements are much more active and lively, and present more seeming spontaneity than those of any of the Diatoms. The employment of the word *spontaneous* to signify the sort of movement of these organisms is certainly unjustifiable, if understood at all in its usual signification, of an act originating in the moving body directed to a special purpose; for no more spontaneity is manifested in the motions of these silicious organisms than in those of the leaves of the *Dionæa muscipula* when any particle impinges on their sensitive hairs. Meneghini, in examining this point, is compelled to admit that no absolute proof is deducible from the movements of the frustules, in support of their animal nature; and the only difficulty to him against admitting that they may be vegetable in character, is, that they are so different from those of Oscillatoriæ, Desmidieæ, and Protococcoideæ,—a worthless objection, to be sufficiently answered by asking whether that motion does not differ as widely from that of any animals, and whether the movements of the Desmidieæ are not equally unlike those of the Oscillatoriæ as those of the *Protococcus*.

The locomotive organs insisted on—consisting, according to Ehrenberg, of a retractile foot and of retractile ciliary processes—have not been sufficiently demonstrated to use as an argument. Ehrenberg, Corda, and more lately Focke, are the only observers who pretend to have seen such organs, although the organisms said to possess them are subjects of daily minute research by hundreds of wonder-finding microscopists. The mucous film which invests many Diatomaceous frustules may, indeed, have been seen and misinterpreted. Meneghini calls attention to a kind of sparkling or agitation—actually a rapid and indeterminate change in the refraction of light at their extremities, which he seems disposed to believe shadows forth the presence there of some sort of ciliary locomotive organs. Granting, however, that cilia were ascertained to be the cause of the movements perceived, the doctrine of animality would in no way be advantaged, since cilia are not peculiarly animal structures.

According to Nägeli, one sort of vegetable movements originates in the act of growth. Of such a kind are probably the vibrations of the Oscillatoriæ; and possibly the motions of the Diatoms are in some degree reducible to the same category. And it is to be remarked that these motions are not equally apparent and active under all circumstances, even among specimens of the same species, but are most so when the vital phenomena of the organisms are most aroused—when the most rapid interchange of material is going on between the external medium and the internal cavity.

2. The second argument rests entirely upon hypothetical grounds, derived from Ehrenberg's observations, and is valueless so long as those observations are unconfirmed. It seems quite clear that the central opening or umbilicus spoken of has no real existence; and if this be so, then the apparent entrance of colouring matter within a set of corpuscles situated around it must be an error of observation, unless the unproved and improbable assumption be made that the colour-particles enter at foramina placed elsewhere (as at the extremities), and become transmitted to these centrally placed sacs or so-called stomachs. Kützing declares that the seeming entrance of colour-granules is the result of mechanical causes, and adds the more important statement that the central collection of vesicles is often wanting.

3. The third argument, that a resemblance obtains between the shells of Bacillaria and those of some Molluscous animals, is, to say the least, fanciful, and in a scientific inquiry can be admitted to prove nothing. If external similarity proved anything, it might as well be adduced to demonstrate the affinity of a lead-tree with the higher plants, whilst, again, the error to which this sort of proof will lead is well exemplified in the case of the Foraminifera, which from mere outward resemblance were for years accounted members of the Cephalopodous family. In the latter instance, indeed, the similarity in external form was very striking—far exceeding that of any Diatom with any testaceous animal.

Kützing, in his review of this assigned reason for their animality, meets it in another way, by observing that, among the cells of higher plants, examples are to be found which in configuration and other particulars agree with Diatoms—for instance, the numerous forms of pollen with their angles, spines,

&c. But, as Meneghini remarks, "he might have added the more appropriate instance of the Desmidieæ, which would be very closely allied to the Diatomeæ, if the latter, like the former, could be referred to the vegetable kingdom. If not equal in constancy and regularity, the Desmidieæ display a greater degree of complication: and we must remember the different nature of their substance; for in the vegetable cell, when lime or silica predominates, the wall becomes uniform and regular."

4. Multiplication by self-division was at one time cited by Ehrenberg as peculiarly an animal phenomenon,—a notion at variance with the observations of every naturalist, and now requiring no refutation. However, Meneghini has more recently advanced the statement that an essential difference in the process of fission prevails between the Diatomeæ on the one hand and the Desmidieæ and Algæ in general on the other, applying to the former modification (in accordance with Brébisson's views) the term *deduplication*, to the latter *reduplication*. To extract his remarks (*op. cit.* 368)—"Division is always longitudinal, and takes place underneath a fine external silicious membrane, by the formation of contiguous diaphragm walls which divide the internal cavity. Thus the contents are longitudinally divided; and this division is *complete* if the two new individuals detach themselves and so acquire individual liberty. It is imperfect if the fine silicious persistent membrane and the secreted gelatinous substance retain them connected together. This mode of reproduction (which Brébisson distinguished by the name of *duplication* and *deduplication*, from the reduplication of Desmidieæ) deserves the most attentive observation. The foregoing exposition presents the fact in its most rude and superficial general appearance, and makes us feel acutely the want of a more circumstantial description peculiar to various forms. It is only after having established facts relative at least to the principal generic types, that we can establish, on a scientific basis, the general idea of multiplication by duplication. A few observations suffice, however, to prove that this does not occur in so simple a manner as we are taught to believe, by comparing it with that in vegetable cells. In the Achnanthidia, for example, it is described and figured that the principal surfaces, which occupy the intermediate space between the two superior and the inferior valves, commence by presenting fine transverse lines, and next a strong longitudinal line along the middle; then there appear two new intermediate valves contiguous to each other—the superior valve (?) of the new inferior individual, and the inferior one of the superior. My observations convince me that the affair does not proceed with so much simplicity. I have often seen the two lateral valves separated, and the intermediate space thus largely amplified. In other cases there appeared only a new inferior valve complementary to the superior, the inferior individual thus remaining incomplete. Finally, in others, between the complete superior individual and the incomplete inferior valve, there appeared a new individual with both its valves, but nearer together, smaller, finer, with lines much less distinct." In short, "in this phenomenon there is more complication than that of a simple cellular deduplication."

5. In a previous page (p. 88) we have quoted Schleiden's notice of a difficulty in the way of recognizing Diatoms to be plants. It is one likewise which has presented itself to others, for instance, to Prof. Bailey and Meneghini. "If we suppose them to be plants," says the latter writer, "we must admit every frustule, every *Navicula*, to be a cell. We must suppose this cell with walls penetrated by silica developed within another cell of a different nature, at least in every case where there is a distinct pedicle or investing tube. In this silicious wall we must recognize a complication certainly unequalled in the vegetable kingdom." (*op. cit.* p. 372.)

This critique of Meneghini loses much of its force when it is noticed that the existence of a pedicle, or isthmus, or of a muco-gelatinous sheath enveloping the frustules, is assumed by him, quite hypothetically, to indicate their formation within a cell-wall represented by the soft investment,—an idea originated by him because he could not admit of an extra-cellular formation. The present state of knowledge, however, clearly recognizes the not infrequent formation of extra-cellular matters about cells, and consequently this portion of the difficulty in question will cease to have importance.

On the other hand, no animals can be pointed out having a similar complex silicious structure, whilst an analogy may be, to a certain extent, found with the Desmidieæ, some of which have a small deposit of silica in their envelopes, which again in some Diatomaceous frustules is very deficient (see p. 37).

Indeed, the affinity between the Desmidieæ and the Diatomeæ is manifested by the differential characters which naturalists feel themselves called upon to indicate (see p. 95).

The composite structure of the frustules is principally the result of the permeation of the external tunic with silex. The little box or capsule, when first produced, represents a simple enclosed cell, imbued with more silica than a Desmidiaceous frond, but otherwise not histologically unlike. When the little being prepares for self-division, the opposite valves separate, much as the opposed halves of a frond of one of the Desmidieæ, and the intermediate production, according to the habit of the class, becomes penetrated by silica (to a less extent, however, than the original valves), and assumes so much of a permanent character that it is very frequently considered an independent third segment.

So again, the cellular, or areolate, or otherwise figured and involuted surface of the frustules, cited by Meneghini as dissimilar to any plant-structure, would also appear to be a consequence of this permeation of the organic membrane with silica, and of various modifications consequent thereon. To show that analogies are not wanting in the vegetable kingdom of curiously modified and figured cell-walls, we may mention as examples, besides pollen-grains, instanced by Kützing, the sporangia of Desmidieæ and of various Algæ. Moreover, the capability of the simplest enclosing membrane to develope a very complex superficial structure is illustrated in the case of the *Rhizopodes*, among which are many examples of striated, areolated, and otherwise modified shells, which, in the eyes of many, range with unicellular organisms. We must not forget to state that Meneghini himself seems to have appreciated the effect of the permeation of silica upon the characters of the cell-wall; for he says, in his supplementary annotations (*op. cit.* p. 511), "the part which silex takes in the formation of the cell-wall is undeniable," as in the epidermis of Gramineæ, Palms, and Equiseta. "The stomatic cells of Equiseta merit particular attention, both from the silex they contain, and the transverse striæ they present on the internal surface. This resemblance to the shield of Diatomeæ might lead us to believe that we ought to regard it as an argument for maintaining the vegetability of the latter: but I do not think that I ought to dwell upon such an objection; I only notice it because I would not appear to be, or pretend to be, unacquainted with it. Yet it seems to me important in another point of view—the apparent complication that the simple cell may assume when penetrated by silica."

We cannot do better than close this part of the argument by Prof. Smith's review of the subject (*Synops.* ii. p. xix):—"In every case this membrane [of the frustule] is more or less penetrated or imbued with silex; and the presence of this substance appears to have modified the intimate structure of the membrane, and induced great variety in the mode and character of its formation in different genera, accompanied by great regularity in the individual species.

"These variations exhibit themselves in the different modifications of structure which constitute the markings of the valves, appearing under the form of ribs and nodules, costæ, striæ, or cellules of an elliptical, circular, or hexagonal outline. A wide comparison of specimens seems to me to prove that these various markings originate in the tendency impressed upon all organized structure to develope itself upon the type of the cell, and that the presence of the silicious constituent in the cell-membrane of the Diatom gives a fixedness to this tendency, which, in ordinary cases, is either not discernible in the structure of the membrane, or whose effect is obliterated by the coalescence of the softer material which constitutes its substance. However this may be, it appears to me certain that the structure of the silicious valve in the Diatomaceæ is invariably cellulate, the cellules being more or less modified according to the peculiar requirements of each species, and that no other explanation of their characteristic markings seems consistent with the facts which are established by a careful examination and comprehensive knowledge of Diatomaceous structure. That this explanation does not involve considerations at variance with the conditions of unicellular vegetable life, will be obvious to any one familiar with the structure of the silicious epiderm in the Equisetaceæ and Graminaceæ, and the distinctly cellulate structure of many pollen-grains, while this very presence of silex as a constituent of the cell-wall in the Diatomaceæ appears to be wholly unaccountable except on the supposition of the vegetable nature of these organisms. In no instance do we find a parallel condition in the animal kingdom (for the secretion of silicious spicula, as an *internal* skeleton, in some of the Spongideæ, cannot be regarded as an analogous phenomenon), whereas the vegetable kingdom furnishes us with cases, not merely of the secretion of silex as a vegetable product in the Bamboo, but with frequent instances of its intimate union with cellulose in the membrane which forms the epiderm of the cell, as in the Natural Orders already mentioned, in the Palmaceæ and others."

On the nature and mode of deposition of the silex, Dr. Bailey has advanced the statement that the silica in Phytolitharia, as well as in Diatomeæ, Polycystineæ, and Spongilithes, is not doubly refractive and polarizing, as Ehrenberg described, and that even the admitted exception of *Arachnoidiscus* is not such. The error in supposing it so has originated from the imperfect removal of the dense carbonaceous tissues which are deposited beneath the silica.

6. The final argument we have to consider for the animality of the Diatomeæ is, that the greater affinity in the chemical composition of the contents, *i. e.* of the endochrome or gonimic substance, is with plants, and not with animals. This argument is certainly based on a nice and very difficult-to-be-determined fact. Meneghini insists on it as important. His remarks have already been given in our notice of the contents of the frustules, to which we must refer (p. 47), adding here only some supplementary observations to fully convey his opinions. "Finally," he writes (*op. cit.* p. 366), for this is not a property peculiar to chlorophyll, "I may add that, if a portion of chlorophyll could be demonstrated in the interior of Diatomeæ, this would by no means invalidate their animal nature; we might still suppose they had swallowed it for food. As to the oil-globules" which Kützing represents, Meneghini considers they may be no more than particles of sarcode, which have an oily appearance; and he would observe "that the number and volume of these globules increase considerably after death, and that during life they are situated upon a longitudinal line extending from one extremity to the

other. And," he continues, "I rely upon the observation that there is some motion and successive alteration in them, as if these minute globules mixed with larger ones, and separated again from them." For, to the mind of the Italian naturalist, the hypothesis of stomachs is admissible, although the fact that a polygastric structure (affirmed by Ehrenberg) has not been shown in the ciliated Protozoa is in itself an *à priori* argument that such an organization is not to be found in the Diatomeæ, among which animal characteristics are so much more deficient and indeterminate.

Although, to our apprehension, this argument, based on the differential chemical composition, to the extent it is developed by Meneghini, is incomplete and inconclusive, yet it was a duty to present it, in order that some of the many ardent English microscopists may be induced to attempt the solution of this micro-chemical question.

Rabenhorst, we should not omit to state, describes the colouring matter of Diatomeæ as quite different from the chlorophyll of plants. For instance, he states that the chlorophyll of plants is taken up by alcohol, dissolves with a yellowish-green colour in alkalies, and with muriatic acid acquires an emerald-green colour, whereas the colouring material of Diatomeæ is insoluble in alcohol (although after a time its colour fades), remains unchanged by alkalies, and acquires a pale-green colour with muriatic acid.

It still remains to point out the facts which speak in favour of the vegetable nature of the Diatomaceæ. The following summary was offered by Kützing:—

"1. The great resemblance of compound forms to Algæ, and their development by fission. There are, indeed, compound Infusoria, as Monad-masses and Polypes: but the former are very questionable animals; and the latter have this essential distinction, that the individual animal lives without (external to) its habitation, and moves freely, whereas such *Naviculæ* as *Encyonema*, *Schizonema*, and *Micromega*, and similar genera, grow within the enclosing substance, building themselves up like the cells in the stem of a plant—so vegetating here only as cells. In like manner, the individuals of *Fragilaria*, *Melosira*, *Himantidium*, &c., are steadily fixed, and unable to exhibit animal motion.

"2. The inner soft organic parts, which I have designated gonimic substance, possess, as well in their chemical nature as in their development, peculiarities akin to those met with in the cell-contents of confervoid Algæ.

"This relation is most clearly seen in the genus *Melosira* and its allied forms, which, not only in form, but also in the chemical components of their contained matter (since the presence of chlorophyll is common to all Diatomeæ), are closely allied to the confervoid Algæ.

"3. The development of seeds, or young [as Kützing represents it], occurs here as in undoubted Algæ, but never as in true animals.

"4. The Diatomeæ, and especially the free moving *Naviculæ*, develope, in the sun's rays, an appreciable quantity of oxygen, like all admitted plants.

"The evolution of oxygen, indeed, occurs in green Monads and *Euglenæ*; but this affords no argument for the animality of the Diatomeæ, but renders the animal nature of those Infusoria themselves very doubtful, and the more so as recent observations confirm the idea of the origin of the lower plants themselves from Monads and *Euglenæ*. Wherefore all these comparisons serve to favour the belief in the vegetable nature of Diatomeæ."

To these arguments has been added another, resting on the assumption of conjugation being peculiar to plants; and Mr. Blackwell discovers further evidence of plant-life in the variations of form of the frustules of the same species (*J. M. S.* 1853, i. p. 247).

It is necessary to inquire, *seriatim*, into the real value of the arguments on this, as has been done with those on the other side of the question. Meneghini enters the lists with Kützing, and disputes the conclusions arrived at by him, rather than the facts on which they rest.

The first argument, founded on external resemblance, has little value, and offers no certain indications of affinities. However, taking Kützing's statements in his own words, modern research has added to its weight; for it has proved, what was before only a probability, that the so-called Monad-masses are only of a vegetable nature.

The second reason advanced has been already discussed, whilst the third rests as yet on incomplete observations, and in Meneghini's opinion has an equally strong analogy in animals, for example, "in the ovaries of Polypes and other inferior animals, as in many Ovipara of superior classes. And, in fact, the bag of a spider, with the thousands of small eggs that it contains, seems to me quite as like, as the spore of an Alga, to the organ of propagation of a *Schizonema* or a *Micromega*." These analogies cannot be allowed much weight, whilst it is, on the contrary, pretty clearly ascertained that the sporangia of Diatomeæ produce a brood of young forms within them,—a phenomenon according in all particulars with the mode of reproduction in numerous Algæ and Fungi.

The fourth argument for their vegetable nature must be admitted to possess great importance. Since Kützing enunciated it, the apparent objections against the vital phenomena in question being restricted to plants, have been removed by subsequent inquiry. The green Monads and *Euglenæ*, cited by Kützing, are now recognized to be vegetable, and can no longer cast doubt, by reason of an assumed animal nature, on the fact of the evolution of oxygen being a characteristic of vegetable life. The evolution of oxygen, as Prof. Smith, like every other careful observer, tells us, "may be noticed in any mass of Diatomaceæ during the warmer months of the year, or in gatherings freely exposed to the sun, in the elevated temperature of a confined apartment, during the winter or spring. Under these conditions the water in the vessel becomes covered with minute bubbles of oxygen, and portions of the Diatomaceous stratum are floated up by the buoyancy of the globules of this gas adhering to their frustules. Such phenomena can only be accounted for by supposing that the Diatomaceæ are plants, and that they exhale, like all plants in a state of active vegetation, oxygen from their tissues; but this process is irreconcilable with the hypothesis of their animal nature." (*Synops.* vol. ii. p. xx.)

Prof. Carpenter insists (*Microscope*, p. 469), that the most positive and easily defined distinction between Protophyta and Protozoa "lies in the nature of the aliment, and in the method of its introduction," in each case. "For whilst the Protophyte obtains the materials of its nutrition from the air and moisture that surround it, and possesses the power of detaching oxygen, hydrogen, carbon, and nitrogen from their previous binary combinations, and of uniting them into ternary and quaternary organic compounds (chlorophyll, starch, albumen, &c.), the simplest Protozoon, in common with the highest members of the animal kingdom, seems utterly destitute of any such power, and is dependent for its support upon organic substances previously elaborated by other beings. But further, the Protophyte obtains its nutriment by mere absorption of liquid and gaseous molecules, which penetrate by simple imbibition, whilst the Protozoon, though destitute of any proper stomach, makes (so to speak) a stomach for itself in the substance of its body, into which it ingests the solid particles that constitute its food, and within which it subjects them to a regular process of digestion. Hence the simplest members of the two kingdoms, which can scarcely be distinguished from each other by any *structural* characters, seem to be *physiologically* separable by the mode in which they perform those actions wherein their life most essentially consists."

The process of conjugation has been used as an argument for the vegetable nature of Diatomeæ by Mr. Thwaites and others. This subsequently seemed to be set aside by the observation of apparent conjugation in *Actinophrys* and *Gregarina* observed by Kölliker and Cohn. However, this phenomenon appears again in the ascendant as a vegetable characteristic; for the observations of Mr. Weston (*J. M. S.* 1856, 122), of Leuckart, Lieberkuhn, and others, go to show that the act believed to be one of conjugation in the *Actinophrys*, is not really a process of reproduction, but merely a temporary cohesion: moreover Lieberkuhn (*Mém. de l'Acad. Roy. Belgique*, vol. xvi.) proves that the production of the *Navicellæ* is not necessarily a consequence of the act of conjugation in the *Gregarinæ*.

If future research substantiate the fact that conjugation is essentially a vegetable process, then the nature of the Diatomeæ will no longer be doubtful.

On a review of the arguments urged on each side, and on consideration of the whole structural and vital peculiarities of the Diatomeæ, we are disposed to consider them of a vegetable nature—members of the great family of Algæ, and, together with many other unicellular plants, to constitute a group known by the name of Protophyta. Nägeli, in 1849, took this view, and reckoned the Diatomeæ as one of his eight orders of unicellular Algæ, of which the Desmidiaceæ and Palmellaceæ were other two. How close must be the affinity of the Diatomeæ with the Desmidieæ is shown by the fact of the two families having so long been treated of together under the common head and name of Bacillaria. And although sufficiently decisive characters separate the one set of beings from the other, yet, in the grand phenomena of life and organization, a true homology exists. The difference between some Desmidieæ and Palmelleæ is as much pronounced as it is between the former and some Diatomeæ; and between these several orders, together with the Zygnematæ, various intermediate forms are to be found, which serve as connecting links. Although Mr. Ralfs would not now insist upon the distinctions between the Desmidieæ and Diatomeæ, formerly laid down by him as decisive, yet they may be here reproduced with advantage. 1. In Diatomeæ (*op. cit.* p. 19) "each frustule consists of three pieces, one central, ring-like and continuous all round, and the others lateral." In opposition, Prof. Smith asserts that the central third segment is no essential part of the frustules, but a portion produced, just like that between the opposed valves of Desmidieæ, preparatory to the process of self-fission. 2. "The division is completed by the formation of new portions within the enlarged central piece, which then falls off, or else by a new septum arising at the centre;" but Mr. Ralfs believes that in every case the separation commences internally before it extends to the covering. So far as we can understand the matter, no essential variation in this process prevails in the two families. 3. "Their coverings, with very few exceptions, are silicious, withstand the action of fire and acids, and may be broken, but not bent; the frustules are often rectangular in form, are never warted, and scarcely ever spinous." To these statements it may be replied, that in a few Diatoms the silex is in small quantities in the valves, and that, on the contrary, examples of partially silicious Desmidieæ are known. The action of fire and acids, the capability of being bent or not, are qualities dependent on the relative proportion of silex in the frustules, and are but secondary distinctions. The same may be said of the remaining points mentioned—the rectangular form, and the presence of warts and spines. The form indeed is, at best, of little value in the argument. The rectangular form of the Diatomeæ is doubtless a consequence mainly of the silicious composition: yet it is far from universal among them; for some species are rather orbicular, others sections of cylinders, others capsular, and others again not unlike square sacs with bulging sides and rounded corners. Even where a rectangular outline exists, it is most frequently only in one view; and the most that can be said is, that the lines of junction are in many instances acute. On the other hand, examples of a rectangular outline are to be found among the Desmidieæ and their allies: the junction-surfaces of *Hyalotheca* and *Didymoprium* are at right angles to the sides of the frond; the end view of *Staurastrum tumidum* is as angular as the front view of a *Triceratium*; and the front view of *Euastrum cuneatum* presents decidedly rectangular truncate extremities. So too in the genus *Pediastrum*, formerly enumerated among the Desmidieæ, although now detached as a subfamily and placed between them and the Palmelleæ, examples of an angular outline occur, as in the *Pediastrum Tetras* and other species. As to the production of spines, sufficiently numerous examples exist among the Diatomeæ to prove it no distinctive peculiarity of the Desmidieæ; and although warty expansions or elevations of the surface precisely like those of some Desmidieæ, may not be noticed in Diatomeæ, yet certain exaggerated inflations of the surface are seen in some Diatomeæ, *e. g.* in *Biddulphia pulchella* and *B. regina*. The two next distinctions indicated by Mr. Ralfs are of more consequence, but nevertheless cannot be admitted as demonstrative of an entire difference in nature. They are thus stated:—"Their internal matter is usually brown when recent; and although some species are greenish, or become green after they have been gathered, none are of a truly herbaceous character. Their vesicles bear some resemblance to those in the Desmidieæ; but they are of a yellower colour, and no starch has been detected in them." The last section of this statement must be held as still *sub judice*; the chemistry of the endochrome is too imperfect to afford a safe argument, and the chemical relations of starch and isomeric compounds too little understood. The concluding distinction, "that the Diatomeæ do not conjugate," the researches of Mr. Thwaites have negatived.

To employ the summary of the affinities of the Diatomeæ presented by Prof. Smith (*Synops.* vol. ii. p. xxi):—"The Diatomaceæ, with specialities of their own, have also intimate alliances with the other orders of the Protophyta, resembling the Zygnemaceæ and Desmidiaceæ in the reproductive process,—the Nostochaceæ in the tendency shown by several genera to surround their frustules with frondose masses of mucus, within which linear series of cells are subsequently developed,—the Oscillatorieæ in their movements,—the Palmellaceæ and all the orders I have named, in the self-dividing act by which the individuals of the species are multiplied, or the aggregate of specific life maintained and increased."

Determination of Species and Genera; Varieties; Classification.—The question has been very much discussed of late, what characters of the frustules and of their contents are to be employed in the construction of species? Ehrenberg generally proceeded on the principle of notifying every departure from any one form, assumed to be specific, as representing another species; but this loose plan has been found productive of error and of excessive multiplication of species, inasmuch as shape, or outline, or markings of the surface are not nearly so permanent and distinctive as formerly imagined.

Although in some species the size and figure seem pretty constant, yet in many they are subject to endless variations. Prof. Gregory cites as examples of changeableness of form the three species, *Eunotia gibba*, *Pinnularia divergens*, and *Himantidium bidens*; and he would comprehend several presumed species of *Naviculæ* under the name of *N. varians*. So again Dr. Greville, speaking (*A. N. H.* 1855, p. 258) of the *Grammatophora* (?) *Balfouriana* (Smith), which he erects into a new genus *Diatomella*, observes, "There is greater variation in the relative length and breadth of the frustules than would be likely to occur in other Diatomaceous groups. In some the length is more than equal to twice the breadth, while others are exactly square; and between these two extremes every gradation may be observed; resembling in this inequality *Fragilaria*, *Odontidium*, *Grammatophora*, and other filamentous genera having plano-compressed frustules." But in this very case a difference arises between Dr. Greville and Mr. Smith respecting the value of internal markings as a characteristic distinction; for the latter author remarks, "The absence of a curve in its septa, relied upon by Dr. Greville, I cannot regard as of sufficient importance to constitute a generic distinction, as this feature is scarcely noticeable in some states of *Grammatophora macilenta*, and is uniformly absent in *G. stricta*." (*Synopsis*, vol. ii. p. 44.)

"The size of the mature frustule" (says Prof. Smith, *J. M. S.* 1855, p. 132) "before self-division commences, is, however, dependent upon the idiosyncrasy of the embryo, or upon the circumstances in which its embryonic growth takes place; consequently a very conspicuous diversity in their relative magnitudes may be usually noticed in any large aggregation of individuals, or in the same species collected in different localities.

"It may also be easily conceived that, while a typical outline of its cell must be the characteristic of a certain species, such outline may to some extent be modified by the accidental circumstances which surround the embryo during its earlier growth and development. A lanceolate form may become linear, elliptical, or even somewhat oval, by the pressure of surrounding cells; and acute ends may be transformed into obtuse or rounded extremities.

"Those who understand the process of self-division will see here a sufficient reason for the occurrence of multitudes of frustules deviating from the normal form, or even for the existence of myriads at one spot, all having a form different from the type,—the single embryo from which they have all sprung by self-division (which process stereotypes the shape with which it commences) having from some accidental circumstances become modified in its outline.

"It follows, then, from these considerations, that neither size nor outline is sufficient to enable the observer to determine the species of a Diatomaceous frustule. If he has the means of comparing specimens in sufficient numbers and from various localities, he may fix with tolerable certainty upon the magnitude and form which may be regarded as the average and type of the species; but, without such opportunities, a reliance upon such characters will inevitably lead to the undue multiplication of species and to a confused and erroneous nomenclature."

In the construction of genera, similar difficulties present themselves. Thus, Mr. Brightwell complains (*J. M. S.* i. 252)—"It appears as if we could carry our real knowledge little beyond that of species; and when we attempt to define kinds and groups, we are met on every side by forms which set at nought our definitions. With reference to the species of the present genus (*Triceratium*), looking upon *T. favus* or *T. megastomum* as what we conceive to be the most perfect plan (if any) on which this group is constructed, we find all the species diverging from it, and carrying us to analogous forms in other groups, or lost in them. Placing the perfect triangular form of

T. favus in the centre, we may diverge in lines to a circumference ending in one line, in the long-armed *T. Solennoceros*, itself nearly resembling *Desmidium tridens* or *D. hexaceros*; in another line ending in a form resembling *Desmidium apiculosum*; in another like *Zygoceros rhombus*, especially in the front view; in another analogous to *Amphitetras antediluviana*; and in another to *Campylodiscus cribrosus*."

Next after size and form, markings existing on the surface or within the frustules have been employed as specific and generic characteristics; but with these, as with the former conditions, great uncertainty prevails in their application, as we have already seen in the difference of opinion, regarding some internal markings of *Grammatophora*, between Dr. Greville and Prof. Smith. In like manner the character, the breadth, the relative position and distribution, the distinctness and the number of striæ on the valves, although tolerably constant in some species, are, in the majority, subject to great variation. Then again some naturalists count the number of striæ in a given space, as, for example, in the $\frac{1}{1000}$th of an inch, whilst others advocate counting the entire number in the length of the valve. The latter plan, to all appearance, must afford more certainty, although the trouble of it is much greater; for in the growth of frustules there would seem an expansion of their walls, inducing consequently a displacement of the striæ further apart; and observation does not confirm the opinion, that in the imperfectly developed frustules a smaller number exists, which are added to in course of growth.

However, just as in the case of the form and size, so, in this matter of the superficial markings, there will be variations according as the frustules result from self-division and are stereotyped impressions of an already existing form, or according as they originate from sporangial frustules and may have an individual idiosyncrasy, or be modified in their development by the locality, and by surrounding circumstances, season and the like.

A writer in the *Mic. Journ.* (1855, p. 309) invites notice to another circumstance:—"Sufficient attention has not yet been paid to the sporangial state of the Diatoms. From the observations recorded by Thwaites, Smith, and others, different genera seem to follow different laws on the subject. In *Navicula* this state appears to be always accompanied by a great dilatation of the frustule, and the formation of a strong line or band between the median line and the margin; sometimes the new line is nearly straight and parallel to the median line, except near the nodule, with which it seems connected; sometimes it is curved; but whether both structures occur in the same species, or are indicative of different species, no evidence has hitherto been adduced. . . . . . The striæ appear, however, to preserve nearly the same inclination to the new or intermediate lines which they did in the non-sporangial state to the median line; and hence the direction of the striæ is not sufficient of itself to distinguish species, however good a character it may afford, unless regard be had to the peculiar state of the frustule."

Prof. Smith has endeavoured to frame some general rules for the guidance of naturalists in instituting generic and specific characters, which we cannot do better than subjoin in an abridged form (*J. M. S.* 1855, pp. 132-134; and *Synops.* vol ii. p. xxii). In determining specific character, three circumstances are of essential importance: 1. the structure of the valve; 2. the habitat; 3. the arrangement of endochome in the living frustule.

The first can be applied to both living and dead or fossil specimens, and affords the most constant and obvious characters. "These varieties of structure arise from the modes in which the silex combines with the cellulose of the epiderm; and this combination seems to follow certain and invariable laws, which are subject to no derangement from the external circumstances in which the growth of the embryo may take place. The structure of the valve reveals itself in the character of the striation, which may therefore be found a good specific distinction." Thus the striæ may be costate or moniliform, parallel or radiate, reach the median line or be absent from a greater or lesser portion of the surface, &c. The relative distances and the distinctness of the striæ are also other features to be recorded, allowance being made for the influence of localities and of age, and for the fact of their having originated from the same or from different sporangia.

Next to striation in importance is locality, which will often aid to discriminate between closely allied forms, since fresh- and salt-water species cannot exchange habitats. Locality also seems even more restricted by other external conditions of a more limited nature.

Lastly, the arrangement of the endochrome confers a specific character more certain than habitat. Examples of various arrangement of gonimic substance, and of the large, constant, oil-like globules, have been already given.

It follows, therefore, that the difficulty of defining species is much enhanced where examples occur only in a fossil state. Even in the living state, shape and size cannot be implicitly relied on, but gatherings are required from different localities, and every condition of growth observed, before an average size or a typical outline can be decided on. And although striation is an important guide, it often happens that this feature is so nearly alike in allied species of the simple forms, such as *Cocconema*, *Cymbella*, and *Navicula*, that our determination must be influenced by less important considerations, and the habitat, outline, and arrangement of cell-contents all require to be brought under review before we should feel justified in constituting a species.

In the construction of genera, the several conditions (viz. form, size, striation, habitat, and disposition of endochrome) employed in the determination of species are also resorted to. Other peculiarities, however, are noted, such as the transverse or longitudinal lines or bands, indicating thickenings of the valves, the presence of a central spot (umbilicus) or of terminal ones, and (as Prof. Smith mentions) "the obvious varieties of form or combination to which the cellules submit in the progress of their formation, exhibiting themselves as hexagonal, circular, or irregular in outline, as distinct from each other, or as more or less confluent." (*Synops.* vol. ii. p. xxiv.)

Kützing has extensively used the circumstance of the presence or absence, the number and the position of apparent pores, not only in constituting genera, but also the higher divisions, families and orders. The figure of frustules on a transverse section, or an end view, is another point he has resorted to in framing his classification. He would, indeed, appear to assign a yet higher importance to the central spot or umbilicus than Ehrenberg himself, since he has distinguished his tribes *Striatæ* and *Vittatæ*, respectively, into two orders, *Stomaticæ* and *Astomaticæ*, according as this structural peculiarity is present or absent. So, again, in the case of the *Navicular* frustules, he has constituted *Surirella* with some other genera into a family *Surirelleæ*, separated from *Navicula*, *Pinnularia*, and other genera, and placed in a distinct order of *Striatæ*, because the former group is destitute of an umbilicus (hence *Astomaticæ*), which the latter possesses (the *Stomaticæ*). Moreover, as the family Naviculeæ, along with others, presented an umbilicus on each valve of their frustule, the term *Distomaticæ* was applied to distinguish them from other families having an umbilicus only on one valve—*Monostomaticæ*. In this plan, therefore, Kützing assigned to the circumstance of striation an altogether secondary place to that of the existence of a central umbilicus, asserting that the presence or absence of transverse striæ was inconstant, and therefore not to be used in generic distinctions.

Meneghini critically reviews Kützing's system of classification, and points out many anomalies and errors in it. "In the three proposed tribes," remarks this author, "we have unnatural dismemberments and associations. The same conclusion prevails also in respect to the six orders, as well as to the ulterior divisions in the first two, taken from the continuity or interruption of the striæ and the presence of one or two stomatic apertures" (*op. cit.* p. 492). For instance, he asserts that the character of the median aperture, given as distinctive of *Tabellarieæ* from *Striatelleæ*, is absolutely false; and he doubts generally of the presence, constancy, and value of a median aperture in framing such distinctions as Kützing has done. The *Actinisceæ* he would separate from the Diatomeæ.

Again, proceeding on the principle that no one character can be allowed an absolute value, he divides the Diatomeæ into two sections, the *Actinisceæ* and *Loricatæ*. Of the latter he would create 8 families:—1. *Eunotieæ*; 2. *Fragilarieæ* (uniting with them the *Meridieæ*, *Striatelleæ*, and *Tabellarieæ*); 3. *Melosireæ*, comprising the *Coscinodisceæ*, *Tripodisceæ*, *Anguliferæ*, *Biddulphieæ*, and *Angulatæ*; 4. *Cocconeideæ*; 5. *Achnantheæ*; 6. *Cymbelleæ*; 7. *Naviculeæ* (with all the *Surirelleæ*); 8. *Gomphonemeæ* (with all the *Licmophoreæ*, except the genus *Licmophora*)."

To the presence or absence of an external muco-gelatinous investment around the silicious frustules, this naturalist gave little weight in framing a classification, reckoning it, together with the existence or not of a pedicle or of concatenation, as scarcely admissible in the identification of species.

On the other hand, Prof. Smith has employed these circumstances, considered in relation to the process of self-division, as the basis of his system of classification. He would look to the phenomena of reproduction as the most sure basis; but in the absence of precise information, except in a few instances, these are at present inapplicable, and self-division seems to him "to come next in order, as a most important function connected with increase and growth, and to supply the necessary variety of phenomena on which to ground our sectional divisions." And he thus proceeds to explain his plan (*Synops.* i. p. xxviii):—

"I have therefore separated those forms where self-division is accompanied by the secretion of a permanent gelatinous or membranaceous envelope, in which the frustules are subsequently imbedded, from those in which such secretion is altogether absent, or is represented merely by a cushion or stipes, to which the frustules are attached by a small portion of their surface; and I have placed the latter, as of simpler organization, in my first tribe, arranging the genera belonging to it into subtribes, depending upon the permanency or otherwise of the connecting-membrane, another product of the self-dividing process. This enables me to place apart those genera whose species present us with frustules in which the union of the cells is dissolved almost immediately upon the completion of self-division, as well as those where a cushion or stipes still maintains a kind of indirect individuality in the divided frustules, from the genera in which the cells cohere after gemmiparous increase, and by such coherence form filaments of various lengths and forms, allotting the latter to subtribes which respectively present a compressed filament, a zigzag chain, or a cylindrical thread. In the second tribe, including those genera which have frondose forms, I find characters for my subtribes in the nature of the frond and the arrangement of the frustules.

"I do not propose this arrangement as free from exceptions or even serious defects; but I have adopted it in preference to those hitherto given, as bringing more frequently together forms allied in structure and mode of growth, and as being at the same time more strictly in accordance with the external physiognomics of these organisms, and therefore more likely to be apprehended by the inquirer entering upon the study of this department of nature. A wider study of Diatomaceous forms will doubtless lead to more accurate and more natural generalizations."

We subjoin the systems of classification proposed by Kützing and by Smith. The former is presented in a tabular form—

DIATOMEÆ.

Tribe I. Striatæ.	Order I. Astomaticæ. Without a central opening on the secondary side.	* Transverse striæ unbroken.	
		Family 1. Eunoticeæ.	
		—— 2. Meridieæ.	
		—— 3. Fragilarieæ.	
		** Striæ broken (interrupted) in the median line.	
		Family 4. Melosireæ.	
		—— 5. Surirelleæ.	
	Order II. Stomaticæ. With the central opening.	*a.* Monostomaticæ.	Having a median aperture on only one of the two secondary surfaces.
		Family 6. Cocconeideæ.	
		—— 7. Achnantheæ.	
		b. Distomaticæ.	With a median aperture on each secondary surface.
		Family 8. Cymbelleæ.	
		—— 9. Gomphonemeæ.	
		—— 10. Naviculeæ.	
Tribe II. Vittatæ.	Order I. Astomaticæ. Without median aperture on secondary side.	—— 11. Licmophoreæ.	
		—— 12. Striatelleæ.	
	Order II. Stomaticæ. With a large distinct one.	—— 13. Tabellarieæ.	
Tribe III. Areolatæ.	Order I. Disciformæ.	—— 14. Coscinodisceæ.	
		—— 15. Anguliferæ.	
	Order II. Appendiculatæ. Appended doubtful forms.	—— 16. Tripodisceæ.	
		—— 17. Biddulphieæ.	
		—— 18. Angulatæ.	
		—— 19. Actinisceæ.	

The Synoptical Table of Prof. Smith contains only those genera then known in Britain; but since the date of its publication not a few others have been added to the list.

Class CRYPTOGAMIA.

Subclass ALGÆ. Natural Order DIATOMACEÆ.

Plant a Frustule; consisting of a unilocular or imperfectly septate cell invested with a bivalve silicious epidermis. Gemmiparous increase, by

SELF-DIVISION; during which process the cell secretes a more or less silicious CONNECTING MEMBRANE. REPRODUCTION, by CONJUGATION and the formation of Sporangia.

TRIBE I. *Frustules naked; not imbedded in gelatine nor enclosed in membranaceous tubes.*

SUBTRIBE 1. *Connecting membrane deciduous; frustules solitary or during self-division in pairs, rarely in greater numbers, adherent or free, dispersed, or aggregated into a mucous stratum.*

22 GENERA. Epithemia, Eunotia, Cymbella, Amphora, Cocconeis, Coscinodiscus, Eupodiscus, Actinocyclus, Arachnoidiscus, Triceratium, Cyclotella, Campylodiscus, Surirella, Tryblionella, Cymatopleura, Nitzschia, Amphiprora, Amphipleura, Navicula, Pinnularia, Stauroneis, Pleurosigma.

SUBTRIBE 2. *Connecting membrane subpersistent; frustules after self-division attached by a gelatinous cushion, or dichotomous stipes.*

7 GENERA. Synedra, Doryphora, Cocconema, Gomphonema, Podosphenia, Rhipidophora, Licmophora.

SUBTRIBE 3. *Connecting membrane evanescent, or obsolete; frustules after self-division united into a compressed filament.*

12 GENERA. Meridion, Bacillaria, Himantidium, Odontidium, Denticula, Fragilaria, Eucampia, Achnanthes, Achnanthidium, Rhabdonema, Striatella, Tetracyclus.

SUBTRIBE 4. *Connecting membrane subpersistent; frustules after self-division united into a zigzag chain.*

6 GENERA. Diatoma, Grammatophora, Tabellaria, Amphitetras, Biddulphia, Isthmia.

SUBTRIBE 5. *Connecting membrane subpersistent as a silicious annulus; frustules after self-division united into a cylindrical filament.*

3 GENERA. Podosira, Melosira, Orthosira.

TRIBE II. *Frustules invested with a gelatinous or membranaceous envelope.*

SUBTRIBE 6. *Frond indefinite, mammillate; frustules scattered.*

1 GENUS. Mastogloia.

SUBTRIBE 7. *Frond definite, compressed or globular; frustules scattered.*

2 GENERA. Dickieia, Berkeleyia.

SUBTRIBE 8. *Frond definite, filamentous; frustules in rows.*

3 GENERA. Encyonema, Colletonema, Schizonema.

SUBTRIBE 9. *Frond definite, filamentous; frustules fasciculated.*

1 GENUS. Homœocladia.

ON THE MODE OF OBTAINING DIATOMEÆ. PREPARATION OF DIATOMACEOUS DEPOSITS MIXED WITH MUD OR IN THE FOSSIL STATE. PRESERVATION OF SPECIMENS.—Many hints on the obtaining of specimens of Diatomeæ are scattered in previous sections of this history of the Order, particularly in that on their habitats (p. 75); yet, to make the directions complete, additional details are necessary.

Where Diatomeæ in the living state exist in any considerable number, they usually form a brilliant cinnamon, or sometimes an olive-brown film or patch, and thereby become visible to the naked eye or to an ordinary lens, adherent to various water-weeds, to decayed portions of wood, leaves, or other floating substances, or as a patch on the mud at the bottom, or otherwise floating on the surface of the pond as a scum or film. Besides such positions and such collections, Diatomeæ exist diffused more or less abundantly through the water or in the mud itself (see p. 75 *et seq.*).

When seen adherent to an aquatic plant, the process of collection is very simple—by carefully gathering or removing the plant from the water and washing it to detach the Diatomaceous frustules, if these cannot be more advantageously viewed whilst still adherent to its stem or leaves. So, too, where, mostly in conjunction with other organisms, the Diatomeæ float in mass, like a scum on the surface, nothing is easier than to lightly skim the collection from the surface. But when the layer of frustules reposes on the surface, or is more or less intermixed with the mud, some additional precautions are required in their collection, unless indeed the film has sufficient tenacity, by cohesion of its component frustules, as in the case of Schizonemeæ, to allow of its being raised *en masse* upon some thin flat instrument, a spoon or spatula, insinuated beneath it.

The general methods of collection applicable to the Desmidieæ and other minute Algæ are equally so to the Diatomeæ, whilst various modifications will suggest themselves to the mind of every practical naturalist to meet the varying circumstances under which he makes the collection. Mr. Ralfs has kindly furnished us with notes on this point. He writes—"It is often difficult to procure clear specimens of those species which form strata on mud; most of them, however, can be obtained, tolerably free from the mud on which they congregate, by the following method, which is applicable both to those found in marine situations and to those gathered from the wayside. When the water is somewhat dried up, if the finger be pressed upon the stratum with a gentle force, the Diatomaceæ will adhere to the finger, and may then be removed by scraping them off upon a piece of linen folded over the edge of a tin box or of a knife; by repeating this process, a sufficient quantity can easily be collected. At first, probably, a portion of mud, especially if very wet, will also be taken up; but a little practice will soon show the force requisite for places where the water is plentiful, and for those where it is nearly dried up. Specimens thus collected can be prepared for mounting with much less trouble than if gathered mixed with a large quantity of dirt."

When it is wished to capture frustules diffused in water, a piece of muslin may be used as a filter, just as for Desmidieæ, and the residue left upon it examined as it is, or, if required, washed, to detach foreign matters mixed with it. Where some admixture of mud is unavoidable, frequent washing of the collected substance will often suffice to separate sufficiently the silicious frustules from the other particles—the heavier grains of sand sinking to the bottom of the vessel, while the Diatoms are still suppended in the fluid; and on the other hand, the decayed organic and other matters, lighter than the frustules, will remain in the supernatant liquid after the latter are precipitated. Repeated careful decanting and washing may be all, therefore, that is required.

Another method applicable to recent living specimens, dependent on the tendency towards the light, at least, of many species, may be adopted by placing the half-liquid mud in shallow pans or plates in the sunshine, when many species may be found to rise as a film on the surface, or to congregate near the edge or sides of the vessel.

When the frustules are much intermixed with mud, which is, under certain circumstances, inevitable, various plans have been adopted for separating them for examination. Mr. Okeden details the following plan, which, with certain modifications to be mentioned, has been described also by Dr. H. Munro :—

"The plan" (*J. M. S.* 1855, pp. 158, 159) "consists in making the deposits fall through a constant depth of water, in various periods of time; thus dividing the Diatoms, according to their sizes, into portions of several different gravities." It is thus carried out: "Take about a cubic inch of the clay to be examined, digest it for about four hours in strong nitric acid at a moderate temperature; now add gradually an equal quantity of hydrochloric acid, effervescence takes place, a further action on the clay ensues; keep boiling for about three hours more, occasionally stirring, and then allow the mixture to cool and settle down, which it will do in about an hour; pour off the superfluous acid and wash the residue repeatedly with water, so as to get rid of the remaining acid.

"The next operation is to divide the sediment into portions of various specific gravities: for this purpose it is necessary to have several beakers, about 3 or 4 inches in height, and about 1½ to 2 inches in diameter; also one very large beaker, about 6 to 9 inches in diameter: we will call the large beaker A. Now transfer the sediment into one of the small beakers, and pour in water till there is just 2 inches depth of water in the glass. Stir, and let stand half a minute by the watch, and then pour off carefully into the large beaker A; repeat this about half a dozen times, each time pouring off into A all that does not fall through the 2 inches of water in the half-minute, and at last the small beaker will contain only what falls through 2 inches of water in half a minute. Now let A stand about half an hour, pour off carefully, and transfer the sediment in A to another small beaker; put 2 inches of water with it, stir and let stand for 2½ minutes, then pour off into A. Repeat this about six times, and there will now be another small beaker containing all that falls through 2 inches of water in 2½ minutes, while in A is all that does *not* fall through that distance in that period. Let A stand half an hour, pour off and transfer the sediment to another small beaker, stir and let it stand *five* minutes, pour off into A as before, and repeat this as before about six times. There is now another beaker, containing all that falls through 2 inches of water in 5 minutes. After this I do not divide them any further, but call the last remainder, or what remains in A after it has stood its half-hour, 'Not in five minutes.' Thus we have four different glasses, containing Diatoms and clay mixed, of four different densities: thus, 0 to ½; ½ to 2½; 2½ to 5; not in 5. There is now a method of concentrating the coarsest of these sediments, namely the 0 to ½, the ½ to 2½, and sometimes the 2½ to 5. It consists in taking the beaker containing the sediment and pouring about an inch of water on it. Let it settle about 5 minutes, and then place the glass on a table, and impart a whirling motion to the whole by moving it round and round, when the greatest portion of the Diatoms will rise up in a sort of eddy, while the particles of mud or sand will remain at the bottom, even though they are of the same specific gravity as the Diatoms, and have fallen through the same distance of water in the same time. This is because the Diatoms are mostly *flat* and *thin*, while the particles of sand and mud are round; in the same way, if we take a round pebble and an oyster-shell both of the same weight, and throw both horizontally into the water, the pebble will reach the bottom sooner than the oyster-shell. So, when the whirling motion is imparted to the glass, the thin flat shells of the Diatoms will rise up in a cloud, while the round particles of mud and sand will remain behind; when the cloud rises up, pour it off quickly and dextrously into another glass, and, if necessary, repeat the process; and a little practice will enable the operator to separate all the Diatoms most effectually. I have said before that this process will only apply to the 0 to $\frac{1}{2}$, $\frac{1}{2}$ to $2\frac{1}{2}$, and sometimes the $2\frac{1}{2}$ to 5 sediment, but not to any finer one; practice will soon teach this. The 'not in 5' cannot be concentrated—it is too fine, and the whole rises together on imparting the whirling motion to it.

"It is not necessary to abide invariably by the divisions of time which I have given here.

"These must be varied, of course, according to the nature of the clay to be examined. For instance, in a clay I have recently tried from 34 feet below the bed of the river at Cardiff, nearly the whole of what was left after the 0 to $\frac{1}{2}$ fell in the $\frac{1}{2}$ to $2\frac{1}{2}$. I therefore divided it thus: 0 to $\frac{1}{2}$, $\frac{1}{2}$ to $1\frac{1}{2}$, and $1\frac{1}{2}$ to $2\frac{1}{2}$; a little practice will soon teach this.

"The advantages of the plan are, I think, obvious. In the first or coarsest sediments we get all the larger and finer Diatoms by themselves, unmixed with, and consequently unobscured by, the innumerable smaller ones and the fine particles of mud and sand, while, if any of them, such as the *Eupodisci* or *Campylodisci*, are rare, they are *sure* to be found in either the first or second division of densities, and by their being concentrated and brought as it were into a small compass, the detection of them is easy and certain.

"In the next division, or the $2\frac{1}{2}$ to 5, we shall find the moderate-sized Diatoms; and lastly, in the 'not in 5,' we get a mass of the remaining and smaller Diatoms, all of which small ones are themselves the more readily seen and identified when separated from their larger brethren.

"I would venture to add, moreover, that I think the examination of these deposits for the various species is much facilitated, as the slides containing the 0 to $1\frac{1}{2}$ sediment may be examined with the inch objective, the $\frac{1}{2}$-inch will do to examine the $1\frac{1}{2}$ to $2\frac{1}{2}$ and $2\frac{1}{2}$ to 5, while the $\frac{1}{4}$-inch need not be used till we come to the 'not in 5;' whereas, were they all mixed, the $\frac{1}{4}$-inch would be required to examine the whole.

"I should add, that what is poured off the large beaker A, after it has stood the half-hour each time, may be flung away and the sediment only transferred to the small beakers, as from the large size of it there will rarely be more than 2 inches depth of water in it, and half-an-hour is ample time to ensure every diatomaceous particle falling to the bottom and being preserved and detected in one or the other of the divisions."

Dr. Munro's plan is a variation of the above proceeding, and is thus detailed (*J. M. S.* 1855, p. 242): "I first boil the deposit in strong hydrochloric acid for five or ten minutes, then allow it to subside, pour off all the acid, and by a few washings get as much of it away as possible; then treat the deposit in the same way with strong nitric acid, washing the deposit by repeated washings to get rid of the remaining acid. When this is done, I then separate the Diatoms according to their different gravities by allowing them to pass through a column of water in the following manner:—

"I take a long glass tube about four feet long and half an inch in bore. At the bottom of this tube is fixed a stop-cock to enable me to let out any of the Diatoms during any stage of the process. Having nearly filled this tube with distilled water, I pour in my deposit washed free from the acids. I watch the deposit as it falls slowly and gradually down the tube, and with a

Coddington lens can easily detect the larger Diatoms as they are precipitated. In about a quarter of an hour, many of the larger forms will have descended to the bottom of the tube. By turning the tap at the bottom of the tube, I let out a drop of the mixture on a slide, and examine it with a low power ($\frac{1}{2}$-inch); and if it be tolerably clear, and the Diatoms of one character, I then let off five or six inches of the mixture into a test-tube, and set it aside for re-examination after the Diatoms have subsided. In a quarter of an hour more, I again let off into another test-tube six or eight inches more of the mixture, and place it aside to settle. In half an hour more I let off into another test-tube six or eight inches of the mixture, which will contain the finer Diatoms by themselves, generally free from all mud and sand. I then pass each of these washings again through the long tube of distilled water; and by examining the mixture during the process of its subsidence, I am enabled to let out the heavier particles of sand or mud, and to obtain pretty clean all those Diatoms which are alike in size, or at all events in specific gravity. Some Diatoms take a longer time than others in settling to the bottom of the tube, and separating themselves from extraneous matter, such as the *Nitzschia*, *Closterium*, &c.; but, by a little patience, and an extra washing through the tube, these difficulties may, in a great measure, be overcome. By this method, I have found the *Pleurosigmata*, *Pinnulariæ*, *Surirellæ*, and *Synedræ* very well separated, those of a like character being found together. I have been stimulated to send these few remarks on the washing of Diatomaceæ, on account of the great difficulty I have hitherto experienced in procuring slides free from mud, sand, and other extraneous matters."

Mr. Okeden offers the following plan for obtaining specimens imbedded in mud at considerable depths, in making borings for engineering purposes. He prefaces the description of his apparatus by that of the usual boring apparatus, which "consists essentially of any number of iron rods" (*J. M. S.* 1854, p. 26), "which screw one into the other; to one of these is screwed an auger or a chisel-point, as the case may require. This is inserted into the ground to be tested, and worked round by manual force and downward pressure, length after length of rod being added as the ground is penetrated. In addition, then, to this apparatus, I obtained, first, several lengths of wrought-iron gas-pipe, about an inch in diameter, and each screwing into the other; and also a similar number of iron rods, each a few inches longer than the lengths of gas-piping, and each also screwing into the other: to the end of one of these lengths of rod is attached a cork of the *exact* diameter of the gas-pipe, or a trifle larger. This cork is fixed by a washer and nut. The gas-piping should be in lengths of about 8 feet each, as this is the most convenient in work: *one* of these lengths should also be again divided into two parts, which must, however, screw and unscrew; and this length is to be the one *first* put into the ground or mud, for reasons which I will presently explain.

"The mode of proceeding is as follows: First, a hole is bored to the required depth—say 20 feet—with the usual boring apparatus; this done, the apparatus is drawn out, the jointed length of gas-pipe is now introduced,—the end of it, with the rod to which the cork is attached, having been previously stopped, the rod passing up the centre of the gas-pipe; this is let down the hole, another length of pipe being attached, and another length of rod, and so on, length after length of pipe and rod, until the bottom of the hole is reached. We shall thus have a continuous length of gas-piping, which will be penetrated by a continuous length of iron rod attached to the cork at the end of the pipe. It is obvious that this cork will entirely prevent any foreign matter from entering the gas-pipe. Having thus reached the bottom of the hole, now pull up the cork into the gas-pipe about 4 feet, by means of the rod attached to it, and then *press* the whole apparatus into the soft mud. The pressure will now drive the mud up into the pipe as far as the cork is drawn up. Now remove the whole apparatus, and by means of the rod push the cork back again to the end of the last length of pipe, when the charge of mud will be driven out in the form of a sausage; and by rejecting the two ends of it, and taking only the middle piece, we may be perfectly sure that the mud at that depth, and that only, has been obtained.

"Having secured the prize, the short length of piping which contained it is now to be unscrewed, and carefully washed with a common gun-cleaning rod and some tow, when it is ready for another experiment.

"With this apparatus, then, I have penetrated Neyland mud in various places to depths of 20, 30, and 40 feet."

The Diatomeæ existing often so abundantly in Guano may be separated on a simpler plan to that pursued in the case of sedimentary deposits and collections of fossil specimens. The proceeding is always preceded by several washings in clear water, and by pouring it off carefully, after allowing a sufficient time for the insoluble and more weighty particles to subside. The subsided matter is then treated with hydrochloric (muriatic) acid several times,—a due interval being allowed for the cessation of effervescence and for the solid particles to settle before the decanting of the liquid and the application of a fresh quantity. When the muriatic acid ceases to produce any chemical action, as evidenced by effervescence, nitric acid should be substituted and used in a similar way two or three times, and the mixture raised to nearly or quite a boiling heat, after which the powder collected at the bottom of the vessel—a conical one should, by the way, be preferred, such as chemists know by the name of "precipitate glasses"—is to be washed repeatedly in pure water. The resultant substance will be found to be composed of silicious particles, which are either Diatomaceous frustules or the silicious spicules of Sponges.

Prof. Bailey, in a recent number of *Silliman's Journal*, 1856 (p. 145), recommends the following method of cleaning Diatomaceous deposits, as more speedy and efficacious than any other he has tried, whether mixed with soundings, guano, or with mud, &c.:—"Dissolve out the lime compounds, if present, by means of nitric or hydrochloric acid, wash, and filter. Then put the moist contents of the filter into a porcelain capsule with enough strong *sulphuric acid* to make the whole a fluid mass. Heat the capsule over a spirit-lamp until the organic matters are all charred, and continue the heat until strong acid fumes are evolved. Keep the capsule hot, and add, in minute portions at a time, finely powdered *chlorate of potassa*. If the acid is hot enough to give off fumes, the chlorate will be immediately decomposed without the accumulation of explosive gases, and it will exert so powerful an oxidizing action, that in a few moments a carbonaceous material as black as ink will become perfectly clean and colourless. Nothing now will remain to be done but to wash off the acid, which is best done by the addition of water and repeated decantations. I would also advise that the materials thus cleaned should not be dried, but should be kept in bottles with a little alcohol, which prevents their felting together, and does not allow the growth of the byssoid plants which often develope in water.

"It is necessary to caution those not familiar with chemistry against using the chlorate of potassa with sulphuric acid in any other way than above directed, as violent and dangerous explosions might result. The process as above given is perfectly safe and very effective."

Another plan of separation of the shells of Diatomeæ or of Foraminifera is successfully adopted by Prof. Bailey and D'Orbigny, and is thus described by the former (*Proceedings of American Assoc. for the Advancement of Science*, 1849, p. 409):—"Where the mixture of inorganic matter is in large proportion to the Infusoria and other microscopic organisms, and corresponds nearly in specific gravity," the deposit is to be thoroughly dried, whereby the minute unbroken shells will become filled with air, and consequently when rapidly stirred up with water they will be buoyed up, and continue suspended after the intermixed sand has settled at the bottom. They may then be easily removed from the surface and transferred by alternately touching the surface of the water with the finger, and the glass slide on which they are to be placed. The sediment, if dried again, will often yield another abundant supply of the minute shells. "By the above means," adds Dr. Bailey, "I have obtained exquisite specimens from the bottom of dried-up ponds, from the sands of harbours, and from the mud attached to floating ice in the Hudson River,—materials presenting the two extremes of very coarse gravel and the finest sediment, neither of which would have given good results by any other process."

In the case of some deposits the shells of the Diatomaceæ are so far the chief constituents, that no preparation is needed before subjecting them to microscopic investigation.

The cohesion of Diatomaceous deposits is at times so great that a difficulty is encountered in separating them. A method of dealing with such is detailed by Prof. Bailey (*Sill. Journ.* 1856, p. 356):—"Many masses of fossil Diatomaceæ are so strongly coherent, that they cannot be diffused in water (for the purpose of mounting in balsam) without a degree of mechanical violence which reduces to fragments many of the most beautiful and interesting forms. This is particularly the case with some specimens from the 'infusorial deposits' of California. Some of these I endeavoured to break up by boiling in water and in acids, and also by repeated freezing and thawing when moistened, but without good results in either case. At last it occurred to me that the adherence might be due to a slight portion of a silicious cement, which the cautious use of an alkaline solution might remove without destroying any but the most minute shells of the Diatoms. As the case appeared a desperate one, a 'heroic remedy' was applied, which was, to boil small lumps of the Diatomaceous mass in a strong solution of caustic potassa or soda. This proved to be perfectly efficacious, as the masses under this treatment rapidly split up along the planes of lamination and then crumbled to mud, which, being immediately poured into a large quantity of water, ceased to be acted upon by the alkali, and gave, when thoroughly washed, not only all the large shells of the Diatoms in a state of unhoped-for perfection, but also furnished abundance of the minute forms. Having obtained by this method highly satisfactory results from specimens from many localities, I can confidently recommend it as an addition to our modes of research.

"The following directions will enable any one to apply the process:—Put small lumps of the mass to be examined into a test tube, with enough of a solution of caustic potassa or soda to cover them; then boil over a spirit-lamp for a few seconds, or a few minutes, as the case may require. If the solution is sufficiently strong, the masses will rapidly crumble to mud, which must be poured *at once* into a large quantity of water, which, after subsidence, is removed by decantation. If the mass resists the action of the alkaline liquor, a still stronger solution should be tried, as, while some specimens break up instantly in a weak solution of alkali, others require that it should be of the consistence of a dense syrup. The mud also should be poured off as fast as it forms, so as to remain as short a time as possible in the caustic ley.

"The only specimens which I have found not to give good results by the method above described, are those from Tampa Bay, Florida, and the infusorial marls from Barbadoes. In the masses from Tampa the lapidification is so complete that the alkali destroys the shells before the lumps break up; and in the case of the Barbadoes marls the cementing material is calcareous, and requires a dilute acid for its removal. In applying the above process, one caution is necessary, which is to thoroughly wash the shells with *water*, and not with acids, as the latter will cause the deposit of a portion of the dissolved silica, and materially injure the beauty of the specimens. When the washings are no longer alkaline, the specimens may be thoroughly cleansed by acids, or by the chlorate process described above."

A very ingenious plan of getting transverse and oblique sections of Diatomaceous shells is mentioned by Schleiden (*Principles of Botany, translated by Lankester*, p. 594), which is precisely similar to that for obtaining transverse sections of hair, as first given in *Pritchard's Microscopic Objects*. It consists in mixing any very pure deposit with mucilage, and, before the mixture is completely hardened, cutting off delicate slices with a razor or sharp knife. The preservation of Diatomeæ for examination is, on account of their silicious composition, easy; and it is only in the case of the stalked, filamentous, and frondose species that any special arrangements are necessary—except, indeed, those demanded in order to mount them as permanent microscopic preparations.

Before the structure of the silicious epiderm can be made out, the endochrome of living specimens must be destroyed, which can be effected by heating the frustules on a piece of talc or platinum-foil. But where it is wished to preserve them in a fresh state, so that their natural living appearance may as far as possible be retained, immersion in creosote and water is recommended by Mr. Shadbolt. Prof. Smith, however, finds distilled water superior to any mixture, which is not merely unnecessary, but injurious. "If," says the author last mentioned, "the filamentous and stipitate forms are not mounted in a fresh state, the frustules separate from each other, part from their stipes, and lose their characteristic appearance. To remedy these inconveniences, I immerse such specimens as cannot be placed in cells when freshly gathered, in spirits of wine and water, one part of the former to six of the latter; and their attachment to their stipes remains afterwards undisturbed, unless violence be employed to separate them."

Fossil, and chemically-prepared and dried specimens are usually preserved in Canada balsam, which is heated and rendered fluid, so that it enters within the cavity of the frustules. The fluidity of the balsam is increased by the addition of a little turpentine or rectified spirit. The presence of balsam, however, obscures the markings of the silicious epiderm; and it has been found better, where the resolution or determination of the superficial sculpturing is very difficult, to mount the frustules, in a dry state, on a thin object-glass, and under cover of a very thin piece. "To prevent the admission of moisture, which would ultimately make its way to the object and destroy its value, it is indispensable that the cover should be cemented to the thin glass below." (*Synops.* i. p. xxxii.)

In a collection of Diatomeæ, we may, by a magnifier, such as a Coddington lens, select certain specimens from the rest to be mounted. This can be effected, when the size permits, by the projecting terminal hairs of a fine camel-hair pencil, or by the moistened tip of a needle; but if the shell be too minute for this, a single stout hair or bristle will frequently suffice, and more satisfactorily and readily if the hair be split at the end. Prof. Redfern, of Aberdeen, pointed out the advantage of split hairs for the purpose, in a brief communication to the *J. M. S.* 1853, p. 235. He recommends a hair, split into three to five or six parts at one extremity, to be fixed by the other in a piece of cork, and held in a common needle-holder. Such split hairs are common enough in an old shaving-brush ; but the divergence of the split portions should be so slight that, until pressed upon, the hair should appear single and unbroken. He has also found entire hairs very useful when set in needle-holders in a similar manner. The split hairs act like forceps, expanding by pressure so as to embrace the object, and closing upon it by their elasticity when the pressure is withdrawn.

To select certain portions of a collection of Diatomeæ from others, Dr. Carpenter gives these directions (*The Microscope*, p. 340) :—" Either of the two following modes may be put in practice.. A small portion of the sediment being taken up in the dipping-tube, and allowed to escape upon the slide, so as to form a long narrow line upon it, this is to be examined with the lowest power with which the object we are in search of can be distinguished; and when one of the specimens has been found, it may be taken up, if possible, on the point of the hair, and transferred to a new slide, to which it may be made to adhere by first breathing on its surface. But if it be found impracticable thus to remove the specimens, on account of their minuteness, they may be pushed to one side of the slide on which they are lying; all the remainder of the sediment which it is not desired to preserve may be washed off; and the objects may then be pushed back into the middle of the slide, and mounted in any way that may be desired." See Goring and Pritchard's *Microscopic Illustrations*, *Microscopic Cabinet*, and *Micrographia* for much original information on these matters.

Sect. II.—OF THE PHYTOZOA.

(Plates XVIII. XIX. XX. and XXVI.)

The Beings included under this Name: their General Character.—Division into Groups or Tribes.—The collection of microscopic beings we would comprehend under the term Phytozoa comprises most of the *Anentera* of Ehrenberg, with the exception of *Amœbæa, Arcellina, Dinobryina, Bacillaria, Closterina, Peridiniæa,* and *Cyclidina.* After excluding these families, there remain *Monadina, Cryptomonadina, Hydromorina, Volvocina, Vibrionia,* and *Astasiæa,* which, although they exhibit great diversity among themselves, nevertheless have certain characters in common, whilst their mutual differences in essential particulars of organization and vital endowments are less than those separating them from the ciliated animalcules. On the other hand, they—at least the majority—exhibit very marked genuine affinities with the Diatomeæ and Desmidieæ as plants. In point of fact, these organisms stand on the confines between the animal and vegetable kingdoms,—some genera distinctly belonging to the latter, others doubtfully to the former, whilst many pass through such phases of existence that at one time they assume the characters of animals, at another those of plants.

This apparently mixed animal and vegetable nature is expressed by the term Phytozoa, derived from two Greek words, signifying plant-animals. Another term, used by Perty, viz. *Phytozoida,* is a simple expansion of the word *Phytozoa,* signifying literally animal-*like* plants. Cohn employs in its stead the term *Flagellata,* derived from the locomotive organ or *flagellum* which most species possess, whilst others prefer the word *Flabellifera.*

In the opinion of the majority of modern writers, the Phytozoa are in general undistinguishable from unicellular Algæ, among the different families of which they consequently seek to distribute them; and doubtless the creation of such a group is purely artificial, and cannot be admitted in any attempted philosophical or natural classification of microscopic organisms. However, since so much uncertainty and dispute still prevail on the question of the animal or vegetable nature of very many, and since our knowledge of the phases of existence of a large number is so imperfect, it is really impossible to establish any satisfactory classification. On this account, and also to bring together for convenience' sake a mass of information respecting several collections of beings enumerated among the *Anenterous Polygastrica* of Ehrenberg, difficult or impossible to arrange under any other heading, we resort to this artificial division, and in so doing have the example of Perty and other writers. After describing what can be predicated of the Phytozoa in general, we shall find it necessary to consider them under several sections or tribes, by reason of the differences which prevail among them in form, mode of growth, and other particulars; and in speaking of each tribe shall point out its general affinities to the others, and to any families of Infusoria or of Algæ.

Figure. Coverings of Phytozoa.—The Phytozoa are of more simple organization and of less varied outline than the ciliated Protozoa. In figure they are commonly round, or oval, or elliptical, and either present no processes, or only an elongated neck bearing one or more cilia (*flabella*) to serve as locomotive organs.

How greatly their figure and size are dependent on the external influence of light, is well shown by some recent researches of Cohn on *Stephanosphæra* (*Nov. Act. Acad. Curios.* xxvi. 1857). On placing specimens of this organism, some in transparent glass vessels, others in semitransparent and green ones, others in porcelain, and others again in perfectly opaque cups, the modifications in size and figure, according to the intensity of light they received, were altogether incredible. In the opaque vessels, where they got little light, the green cells remained delicate, small, and widely dispersed, whilst in the transparent glasses, under sunlight, they became many times larger and crowded together, and their figure fusiform, irregular, and produced into numerous protoplasmic processes. Indeed, on placing two portions of the same collection of *Stephanosphæra*-globes, the one in a transparent, the other in an opaque vessel, the swarming individuals in the two will be found so unlike that they might be readily conceived to be different species.

The outline is fixed where the organism has a firm envelope; and most of the Phytozoa have such in one phase of their existence, viz. when they undergo the encysting-process. We are not acquainted with the entire history of many genera; but from what we know of some, we may argue by analogy of all, that in the earliest stages of existence these cellular organisms have no distinctly organized wall, although they may have a pellicle derived from the contact of the protoplasm, of which they consist, with surrounding media,—a mere superficial induration, but no separable membrane. Such is true of the individual cells of *Volvox* (XX), of *Euglena* (XVIII. 45, 46), and of Monads (XVIII. 1 to 28) in general. Subsequently a cell-wall, the primordial membrane or sac, may be produced, distinct and separable from the contained substance. Furthermore, many examples do not stop here, but proceed to throw out a second wall exterior to the last-named, separated frequently from it by a small interspace, and having a much denser and firmer consistence. The cell, or, as Prof. Henfrey calls it in the case of *Pandorina*, the *gonidium* (XIX. 61), encloses itself, in fact, within a cyst (XIX. 69), and in so doing mostly alters its form materially, loses its previous animal characters, becomes 'still,' and at the same time qualified to sustain life under various adverse external influences, and to continue the species by an ulterior act of development. In all this we trace an exact parallel with the history of the spores of the lower Algæ; and there is no question that many of the Phytozoa are no other than spores, sporozoids, or zoospores. Moreover, it is equally clear that many *Monadina* and *Cryptomonadina* described by Ehrenberg are but two phases of one and the same organism.

Not a few Phytozoa present an additional covering in the shape of a mucilaginous layer. This is found in isolated species, as *Protococcus pluvialis*, and generally in all the aggregated forms; indeed, it is the principal agent in the construction of the latter. It has generally been assumed that this mucilaginous investment is an extracellular product, without a definite boundary; but Cohn (on *Protoccocus*, *R. S.* 1853) has a long argument to prove that the true cell is represented by it, conjointly with the included, coloured, apparent cell. Thus, he writes (p. 531)—"Neither of these bodies are true, perfect cells, inasmuch as the first wants the primordial utricle, and the second is without the true cell-membrane. The two together would represent the perfect cell." Again, it is stated in the same page, "that the internal globular body is not surrounded by any special cellulose-membrane, but only by one readily destroyed by chemical or physical agency—probably nothing more than a dense layer of protoplasm. On the other hand, the external membrane represents a true cell-membrane, enclosing between itself and the coloured substance a colourless aqueous fluid, probably pure or nearly pure water." And in the subsequent considerations of this structure, Cohn appears to arrive at the conviction that the internal coloured body generally spoken of as the cell, the actual unicellular organism, represents the nucleus of a cell, of which the periphery of the mucous envelope is the boundary. In this interpretation of the nature of the mucilaginous envelope, Prof. Williamson concurs. Indeed this accurate observer proceeds, further, to show that there is in the case of *Volvox* a true enclosing delicate membrane to each cell, and that the hexagonal form is owing to the mutual pressure of the aggregated cells (Pl. XX. 38). In aggregate forms, such as *Volvox*, *Gonium*, *Pandorina*, &c., an additional common external membrane would seem to be thrown out, to unite together into one symmetrical whole the various members of the colony. Perhaps it should be rather called a pellicle than a membrane, seeing that its independent existence as a separable structure cannot be demonstrated: yet it has a power of resistance; for when external force is applied to a globe of *Volvox*, the surface, though at first depressed, presently recovers itself by an innate elasticity; and in the case of *Pandorina* it seems so resistant and firm that it does not indent on pressure (XIX. 61).

CELL-CONTENTS.—The fluid distending the mucilaginous envelope around most Phytozoa, in one or other stage of being, is, according to Cohn, as above noticed, probably pure water. This opinion Prof. Williamson does not entertain; for he says (*J. M. S.* 1853, p. 55) "it is apparently mucilage. In a preparation in which a number of these objects [of *Volvox*] are mounted in dilute alcohol, this gummy matter has changed to a brown colour, and refused to mingle with the alcohol, as would be the case supposing it to be mucilaginous. This proves that it is a true secretion from the organism, and not merely water absorbed by endosmosis. . . . The secretion itself is, perhaps, little more than a diluted condition of the same gum as that which is more or less completely converted into cellulose in the various investing membranes."

The central globule, or the whole recognized organism where a mucilaginous envelope is not present, consists of a mass of protoplasm. At first it is homogeneous and without colour; subsequently it becomes generally coloured and granular; but very shortly the included matters gather together into a sort of layer subjacent to the surface, and leave the central part clear, sometimes so completely so that it assumes the appearance of a vacuole. This substance moreover has the property of contractility inherent in it, and would seem, in all essential circumstances, homologous with the simple contractile matter—the sarcode of animalcules. Like the latter, it may hollow itself out into vacuoles at any part; and such, says Cohn (*R. S.* p. 535), "are present in all young cells, and play a considerable part in cell-division and the sap-currents." The property of contractility is singularly displayed in the case of the actively moving zoospores or sporozoids of the Algæ, and in the motile form of *Protococcus*,—*i. e.* in every instance where, from the absence of more or less inelastic membranes, it can exhibit itself. The vacuoles of the protoplasm occur in varying numbers, and change or disappear from time to time: within they contain an aqueous fluid.

The contractile protoplasm is itself colourless; yet, except in the earliest stages of development, it partakes of a green or a red colour, or of both these colours together, save in one spot, which in oblong forms is situated at one end, and in the projection or beak (proboscis, Ehr., or rostellum) extending from the anterior extremity. "It appears," says Cohn (*R. S.* p. 536), "as a delicate, almost imperceptible layer constituting the outer boundary of the coloured primordial cell, the periphery of which then becomes sharply defined, and, as it were, surrounded by a delicate transparent membrane." The green colour is due to chlorophyll vesicles and granules, either diffused or collected in a layer just beneath the surface. Among other contents are also starch-granules without colour, and very frequently globules of oil.

Green or red may exist alone: but more frequently green prevails; and the red pigment, sometimes termed *erythrin* or *erythrophyll*, is seen only at one spot, occasionally at the centre, but usually on one side of it, or at one extremity: when occupying the position last-named, it was looked upon by Ehrenberg as an eye-speck or organ of vision.

Although, as Cohn (*op. cit. R. S.* p. 528) tells us, the green and red colouring matters differ in chemical and physical conditions, yet the one passes into the other. The red or brownish-red colour is formed when the cells become drier; but neither deficiency of water nor the influence of light appears to be the exclusive cause of the transition. It is especially in the transition to red that vesicles of an oily aspect make their appearance. Indeed, that oil is really formed, is supported both by analogy with the spores of many Algæ which clearly secrete that substance, and by the vesicles in question having a similar refraction to oil, and behaving like it with alcohol and ether. "The formation of fixed oil," says Braun (*Rejuv., R. S.* p. 200), "is intimately connected with that of starch in the economy of cell-life; its appearance, in like manner, announces the repose of age in cell-life; its disappearance, the beginning of rejuvenescence. We meet with fixed oil in the cells, either mixed with starch, substituted for it, or gradually displacing it; its occurrence is perhaps still more general than that of starch.... Like the latter, it is met with in greatest abundance in those parts in which vegetation is destined to rest and to await a future re-awakening;" and such are the resting-cells of Phytozoa, in which a red colour predominates or exists alone. Braun furnishes an illustration of this in his remarks on *Chlamydomonas* during its sleeping or resting state (*op. cit.* p. 214). The opinion, moreover, that the so-called red eye-specks of Phytozoa are no other than drops of oil, is shared by Perty (p. 117) and by Nägeli (*Einzell. Alg.* p. 9).

Speaking of *Protococcus*, Cohn remarks (*op. cit.* p. 526), "The red and the green portions of the contents appear to be of equal physiological importance ....When still or motile cells are brought into contact with a very weak watery solution of iodine, they become internally, in most parts, of an intense violet or blue colour." Yet he does not believe this colour to depend, in all instances, upon starch; for the red contents are equally coloured blue, and he therefore surmises there may be some other substance besides starch exhibiting the same reaction with iodine.

Besides diffused chlorophyll-particles, to which the green colour is due, one, two, three, or more large nuclear-like vesicles exist in Phytozoa—indeed, in unicellular plants generally—described by Nägeli under the name of '*chlorophyll utricles or vesicles.*' The number of such in any genus seems commonly to be constant: thus, in *Stephanosphæra* there are two; in *Gonium* only one. However, they are occasionally absent, chiefly so in more minute examples. In *Protococcus* (*Chlamydococcus*), Cohn says they occur principally in the green cells, to the number of one, two, three or more, having the appearance of minute green rings, about 0·002‴ in diameter—the interior being sometimes darker, at others more clear, and frequently almost opake. Nägeli regarded them as minute membranous vesicles, containing a mucus coloured by chlorophyll. Cohn imagined that in *Protococcus* they stood in connexion with the division of the cell, but could not determine with certainty that their number corresponded with that of the secondary cells. Kützing looked upon them as gonidia or cell-nuclei, concerned in the propagation of the individual.

Ehrenberg entertained a similar notion, and called them the testes. "Caustic potash," says Cohn (*A. N. H.* 1852, x. p. 340), "which destroys the rest of the contents of the primordial cells, makes the chlorophyll-utricles of *Stephanosphæra* show themselves more distinctly as hollow rings surrounded by a rather granular membrane; iodine colours them deep violet, which leads to the conclusion of the presence of starch." Iodine sometimes, however, produces a deep brown tint (Cohn, *R. S.* p. 529), due, we may suppose, to an ulterior metamorphosis of the starch, as it is itself a transitional condition of chlorophyll.

Another structure met with among the contents of some of the Phytozoa is the *contractile vesicle* or *sac*. This sac has been noticed in *Volvox*, *Gonium*, *Pandorina*, *Chilomonas*, *Cryptomonas*, and in *Chlamydomonas*, and its rhythmical contractions observed (XIX. 16, 33; XX. 40, 41). In *Stephanosphæra* a similar vesicle was seen by Cohn, but its contractility not detected: so in *Astasia*, *Euglena* (XVIII.), and *Polytoma* (XX. 1, 2), a clear sac-like space presents itself at the anterior extremity, immediately beneath the surface; but its alternate expansion and contraction have not been witnessed.

A *nucleus* is detected in *Euglena*, *Astasia*, *Polytoma* (XX. 1, 2, 3), and others in which an animal nature predominates. Even among the vegetable genera *Volvox*, *Pandorina*, and *Gonium* (XIX. 32, 34, 61), most writers, as already seen, seem disposed to view the constant chlorophyll-vesicles as of a nuclear character. In *Gonium*, indeed, Cohn (*Entw.* p. 178) describes only one such vesicle, which seems to demonstrate its nuclear nature by breaking up, during the process of fission, into as many parts as the primordial cell itself. Braun (*op. cit.* p. 174, in note) mentions his observation of a central vesicle or nucleus in *Chlamydococcus* (XIX. 22, 24, 26), and remarks, "in most of the true Palmellaceæ there is a chlorophyll-vesicle in the centre of the cell."

The appearance of the cells of Phytozoa is much modified by variations in the relative quantity or in the arrangement and colour of the contents, so much so indeed that such varieties have been described as different species or even as different genera. Thus the accidental presence of a red spot, called an eye-speck, or the occurrence of a red central space, have had a specific importance wrongly attached to them. The inutility of characters deduced from the disposition and appearance of the cell-contents, or from the figure, is further shown when the effects of external agents—of temperature, of the abundance or deficiency of nutritive matters, of light, &c.—are taken into account; and it becomes even still more evident when the changes of form one and the same being may undergo are duly considered.

In a previous page it has been stated that in the earliest phase of existence, when the future cell is but one of several macrogonidia within its mother-cell, the protoplasm of which it consists is unenclosed by a membrane—has no cell-wall. But it would seem that a cell-membrane is wanting even at maturity in some genera, for example, in *Stephanosphæra*; for Cohn writes (*A. N. H.* 1852, x. p. 326), "This is not only made evident by the multifold changes of form which they undergo in the course of vegetation, and by the filiform prolongations and ramifications which are produced directly from their substance (XIX. 38, 39–53), but is clearly shown by the transformations which the primordial cells pass through in consequence of external influences. Under certain circumstances namely, the filiform processes may be retracted, being torn away from the envelope-cell and taken up into the substance of the primordial cells; the produced ends of the primordial cells also disappear, the latter becoming rounded off into their original spherical or short cylindrical form. Such a change would be impossible if the primordial cells were surrounded by a rigid membrane, such as that of the envelope-cell for example."

According to Prof. Henfrey, the primordial cells or gonidia of *Pandorina* (XIX. 59–63), and also, in the opinion of many, the *Euglenæ* (XVIII. 45–48), are similarly undefended.

The internal globular coloured body of the motile form of *Protococcus* is in the same state. Thus Cohn (*R. S.* p. 531) points out that although this body has a sharply defined outline, yet, " either by mechanical means, or by chemical reagents, the internal globular mass may suddenly be made to lose its contour, and to spread so as entirely to fill the cavity of the colourless envelope. From which it would appear that the internal globular body is not surrounded by any special cellulose membrane, but only by one readily destroyed by chemical or physical agency—probably nothing more than a dense layer of protoplasm."

In the case of *Volvox* the cells originate without an enclosing membrane; but after the appearance of the red spot, a delicate one shows itself, and extends at different points into the connecting thread-like processes (XX. 37, 39, 41). So in *Gonium* we may presume the primordial cells to be originally naked, although Cohn has not remarked this fact, but confined himself to describing the mature cells (XIX. 32, 34), which have an enclosing wall of cellulose (*Entw.* pp. 175, 176). Lastly, in the 'still' form of *Protococcus* a special membrane invests the protoplasmic gonidium. In *Gonium* (XIX. 34), and in *Volvox* (XX. 37, 39, 40), filiform prolongations extend between the several cells in the compound organism; in *Stephanosphæra* similar processes are given off at the opposite poles of the cells, and are consequently not intercurrent (XIX. 39). Prof. Williamson has in the case of *Volvox* offered the best explanation of these threads, which have by some been supposed intercommunicating canals. He first makes good his opinion that the green cell-like organism represents the nucleus of a cell, the wall of which is separated from it by a greater or less space; and then he compares the processes in question with the filiform extensions from the nucleus which are met with in many vegetable cells, suspending that organ in the centre. In the early stage of the cell, the protoplasmic substance fills up more or less completely the cell-wall (XX. 42, 44): by-and-by the latter becomes outstretched from it by a sort of dropsical effusion within it (XX. 37); but as the protoplasmic nucleus has contracted adhesions at different parts, it becomes drawn out from the adherent points into thread-like processes (XX. 39, 40, 45), which grow more and more filiform in proportion as the cell-wall expands. This explanation (agreeing in every particular with the observed phenomena of cell-growth) being accepted, it follows that these elongations are bounded by the particular cell-wall to which they belong, and are not continuous with those of adjoining cells. The processes of *Volvox* are therefore off-shoots of the protoplasm of which each cell or gonidium consists; they are given off before any enclosing wall or pellicle appears, and whilst that substance is still ductile, and they disappear on the commencement of the process of development, whether of macrogonidia or of microgonidia, and whether with or without the process of encysting.

In the case of *Gonium*, Cohn gives (*Entw.* p. 176) a different account of the connecting bands. It will be remembered that in this genus that observer indicates an enclosing cellulose membrane to each cell or gonidium. Now this cell does not closely invest the protoplasmic substance at all points, but is so separated as to produce a hexagonal cell-wall around it, from each angle of which the membrane is produced in a tubular form, and joins with a similar process coming from the angle of an adjoining cell (XIX. 32, 34). Hence each process of the membrane has a double outline, and is in fact a tube, only that its interior must be presumed to be shut-off from that with which it joins, by a septum representing the divisional membrane of each of the contiguous cells. The state of things here is therefore quite different from that in *Volvox*: for in the latter the cell-membrane is widely detached from the protoplasmic nucleus, but the adjoining cells are adherent at all points; the intercurrent threads are therefore within the cells, and uphold an attachment between the nucleus and the cell-wall,—whilst in *Gonium* the contrary obtains: the cells themselves are not in apposition, but held together by a tubular extension from each angle; and the nuclear protoplasm within nearly fills the cell-cavity, and has no bands uniting it with the wall—in fine, the intercurrent processes of *Gonium* and of *Volvox* are not homologous.

Besides the wall and processes just described, calculated to give strength and resistance to the organisms, there are also the long *cilia or filiform appendages* known as filaments, flabella, or flagella, seen at one extremity of most Phytozoa, derived from the protoplasmic mass. To these are entirely or chiefly due the locomotive powers of these beings; they also act the part of rudders in turning them on themselves, and in directing them hither and thither. They do not belong to the class of vibratile cilia, but are larger, filiform or whip-like, and have an undulating lashing movement. In some cases they are many times longer than the organism to which they are attached (XVIII. 15, 21, 22); and when two, as more frequently happens, are present, they will often cross and intertwine. At times, in elongated forms, they appear to be the mere terminations of the tapering-like extremity or neck; but the rule is, they do not proceed from the apex itself, but from one side of it. Where the species is encased in a firm integument, separated by an interval from the central protoplasm, the filaments actually extend from the latter and perforate the enclosed case; in which, particularly when these processes are fallen away, their points of issue are occasionally to be detected by depressions or by pores. During frequent rapid movements these filaments are not to be seen; but when the motion is more gentle, or they are at rest, or otherwise when colouring matter is mixed with the water, they generally become visible. Even when their existence has not been noticed during life, it may be sometimes demonstrated after the drying up of the being, by the streak left upon the glass where it rested. Where more than one or two filaments are present, their whirling, and the consequent agitation of the fluid about them, makes their existence apparent.

The number of filaments in Phytozoa varies. Two is the prevailing number, which may or may not be of equal length; but in not a few genera only one is found, *e. g.* in *Euglena*, *Monas*, and *Chilomonas*,—whilst in others more than two may be counted, situated together anteriorly, or some in front and others behind. Where two are present anteriorly, it is not an uncommon arrangement for one to extend in the direction of the long axis of the body, whilst the other trails behind (XVIII. 12, 22, 23).

Movements of Phytozoa.—The motion of many Phytozoa is but slow, and rarely intermitted; in others it is more rapid and varied. It will be modified by the figure of the organism and by the degree of firmness of its walls, with which it stands in inverse proportion. In *Euglena* the movements are extremely varied and lively: the being is unrestricted in its movements by an integument, and the contractile protoplasm has full scope; it is, in fact, in the condition of swarming gonidia, unenclosed by a wall of cellulose. In many species of *Monas* and *Bodo* (*Cercomonas*), the motion is irregular and peculiar; it may be oscillating or rolling, at times leaping, at others backward. Among the *Vibrionia* (XVIII. 57–69), an oscillating spiral movement is a common characteristic, and either end may be advanced. The revolving rolling motion of *Volvocineæ* has for many years attracted attention, and for a long time was deemed sufficient proof of the animality of the beings exhibiting it. It is the consequence of the play of the ciliary filaments of each of the component cells of the aggregate organism, which project beyond the common envelope: it consists in a revolution on the axis, and a simultaneous onward movement—not, however, in a straight course, but in an irregular one, representing a spiral or series of curves. "The collective idea of such motions," says Cohn (*A. N. H.* 1852, x. p. 328), "is best represented by the course described by a top, which runs through the most varied curves, while at the same time constantly revolving on its axis."

Nägeli (as quoted in *J. M. S.* i. p. 198) remarks of swarm-cells (zoospores), which many Monads undoubtedly are, that "under the microscope the motion appears very rapid, somewhat of an infusorial character, consisting in a continual progression, in which the hyaline narrower extremity is usually in front, and the cell is continually turning on its long axis. Although the swarming bears a resemblance to the motion of Infusoria (*i. e. of Ciliated Protozoa*), it clearly wants the spontaneity of the latter. The Infusoria advance, spring back, turn round, return, all spontaneously; the swarm-spores pursue a uniform and, for the most part, pretty straight course, deviating from it, or turning round only upon meeting an obstacle, impinging upon which they are diverted into another direction." To this account Siebold (*loc. cit.* p. 201) adds that the spores do not retreat, as if frightened, like the Infusoria, when they strike against an object, but "remain close to it, and continue their motions according to the number and arrangement of their ciliary apparatus, in a rotatory or vibratory way for a little time longer, as if they aimed at overcoming the obstacle by force, until at last, probably in consequence of the death of the cilia, they become still, and germination goes on. . . . . The movements of the swarm-spores in general have only a short duration. After the spores have come to a state of rest, they usually become attached by the hyaline ciliated extremity, and the locomotive faculty is for ever lost." In the aggregated families the process of reproduction is ever going on in some members of the colony, and the movements are kept up much longer. Braun (*Rejuv.*, *R. S.* p. 212) represents *Chlamydococcus* as enjoying a longer duration of motion than is usual with the swarming gonidia of Algæ, whilst *Protococcus viridis* forms an intermediate link in this respect between it and the *Volvocineæ*. The kind of movement, he adds, is essentially the same in these organisms as in all active gonidia, namely an uninterrupted revolution round the long axis, combined with an advance towards the side of the ciliated point. It is, indeed, in the swarming movement of gonidia and spermatozoida that the phenomena of motion are most striking, "that is, in cells which are either yet without their cellulose coating, or which never acquire one."

Cohn (*R. S.* p. 558) states generally that, "leaving out of the question the more highly organized Infusoria furnished with a manifest mouth and œsophagus, the motion of a large part of the *Anentera* (Ehr.), the *Astoma* (Siebold), is not essentially different from that of the zoospores of certain Algæ." Likewise, in his description of *Gonium* (*Entw.* p. 180), he observes that the movements of this organism resemble in every particular those of *Stephanosphæra*, *Chlamydococcus*, and other swarming-cells, "which certainly do not bear at all the character of purposing, conscious volition, but appear as an activity determined not by any external causes, but by *internal* causes in the organization and vital processes." (*A. N. H.* 1852, x. p. 328.)

The character of the locomotion of Phytozoa may be described in brief as 'automatic;' accepting that term as physiologists now agree to do, to distinguish such motion from the voluntary movements of animals. It cannot be voluntary, or the result of volition, any more than the marvellous motion of the leaves of *Dionæa muscipula*.

Process of Nutrition.—The process of nutrition of Phytozoa is of the most simple kind; and no valid evidence can be adduced in proof of the complex polygastric organization represented by Ehrenberg. In fact, an apparatus of stomach-sacs could not, by any analogy, be presumed in a set of beings destitute of mouths; and Ehrenberg was unable to demonstrate, even to his own satisfaction, an oral aperture, except in a very doubtful manner and in a very few instances. What he took to be gastric cells are no other than vacuoles and clear vesicles—sometimes the chlorophyll-cells; the last, however, were more commonly assumed to be 'testes.' To support his belief in the presence of stomachs, and also of a mouth at the anterior clear space, particularly where there is a projection of the protoplasmic mass, the Berlin naturalist appealed with most confidence to his experiments in feeding with coloured substances. By this means he believed he demonstrated such organs in some Monadina,—but so rarely, amid a large number submitted to experiment, and moreover in so few species, that much weight could not be attached to the result, especially when it is considered how many difficulties and doubts must arise where such very minute beings are concerned. Allowing that particles of colour actually entered within the interior, and were not merely adherent (a question which the magnifying powers of the instrument Ehrenberg used could scarcely determine), it is even then much more rational to suppose that their entrance was by mere mechanical causes (by pressure or the like), than by the medium of a mouth. This interpretation is adopted both by Perty and Leuckart, who describe the introduction of such particles as possible, although, indeed, exceedingly rare in the more clearly vegetable structures, the Diatomeæ. The former mentions (*op. cit.* p. 61) three instances in which he encountered foreign particles within the substance of Phytozoa; but these would, instead of supporting, be really opposed to the polygastric hypothesis. For instance, he discovered in a *Peronema* a species of *Bacillaria* as large as itself, and consequently not containable within one of the supposed gastric cells.

In the case of the soft, illoricated minute Monadina, into which fine particles have found their way, it is to be remembered that they are mere masses of yielding protoplasm unprotected by a cuticle; and further, we may, along with Perty, reasonably presume that, in some examples of the entrance of external matters, it has been effected much in the same way as with the *Amœbæ*, by the soft substance overlying and then surrounding them.

If a mouth and stomachs have no existence, it follows that nutrition must be effected by imbibition—by endosmotic and exosmotic action—just as in any simple vegetable or animal cells. Perty (*op. cit.* p. 62) adduces an experiment showing that, to some Phytozoa at least, water rich in nutritive organic material is necessary to their complete and healthy development; for when taken from such water and placed in other quite pure, they dwindled in size, although, curiously enough, they at the same time became more active.

To complete what we have to say of their vital endowments (irrespective, that is, of the reproductive functions), the Phytozoa seek the light; and all their nutritive acts are carried on more actively under its influence. The only exception is when, in the process of propagation, they are about to pass into the 'still' condition and to become encysted; then they eschew the light, sink out of sight, and recede to the bottom, or under cover of aquatic plants or of their debris. Under the influence of light they exhale oxygen gas, and the green colour is especially developed,—whilst when kept in the dark they lose colour, become pale, and present few chlorophyll-particles. The intensity of light may be too great, and destroy life; and a great elevation of temperature is less favourable to vital activity than a moderate one. Cold retards vital action, and if considerable, arrests it, except in the case of the encysted beings, which are so modified by nature as to resist its injurious influence; these consequently persist through the winter when the motile forms are cut off, and in the coming spring burst forth into life. The same provision which imparts to the encysted organisms a tolerance of cold, enables them also to withstand the effects of evaporation, which to the unprotected motile varieties is speedily destructive, unless, indeed, so gradual as to allow them time to pass into the 'still' form.

Starch or cellulose may be detected chemically in the great majority of the Phytozoa; and even where iodine fails to produce the characteristic blue colour during life, it will at times act strongly when a breaking-up of the contents follows evaporation or some other injurious influence. The efficiency of nutrition is manifested by the decided changes, chemical and vital, which are seen in constant operation within the beings—such as, among others, the transformation of chlorophyll into starch, and of one or both these into an oily matter.

When in the 'still' encysted condition (XIX. 44–69), all nutritive changes are at a standstill, and the organism may exist weeks, months, and even years unchanged, until external conditions are supplied to awaken its latent energies and to renew the cycle of life. In this torpid form the spores are carried about with the dust, or remain buried in the earth, or are elsewhere hidden or stored up against the day of revival.

The passage into the 'still' condition by the throwing-out of an external denser envelope and by the loss of cilia, is governed, it would seem, in some measure by external circumstances. Motile forms are replaced by the 'still' in whole or in part, and with greater or less rapidity, by pouring the water containing them into a larger and shallower vessel, and by gradual evaporation.

The protoplasm of Phytozoa being homologous in all perceptible particulars with the 'sarcode' of Protozoa, suffers, like it, the destructive process of 'diffluence' or 'deliquescence' when evaporation reduces the quantity of water around the unprotected motile forms below the quantity necessary to vital action. The first noticeable result of evaporation is, according to Cohn, at least in the instance of *Protococcus* (*op. cit.* p. 538), a more rapid change of figure and appearance, followed, if the evaporation continue, by diffluence, in which he distinguishes two stages or phases:—"In the first, the outlines appear less sharply defined, because the coloured substance is somewhat retracted from the border of the primordial cell; the cells become flattened, and at the same time wider: the contents are also now altered; previously more homogeneous and transparent, they now become throughout granular, and the red substance runs together in large drops. At this time the formation of vacuoles commences; and their number continues to increase. In this way the interior of the primordial cell again becomes colourless, clear as water, and the granular coloured contents pressed against the walls. . . .The figure of the cell in the warm time is so much expanded, that it comes to be applied upon the wall of the enveloping cell, alternately filling it altogether, so that the entire zoospore appears to consist of only a single coloured granular vesicular disc, corresponding in size with the original enveloping cell."

Multiplication and Reproduction of Phytozoa. Fission: Macrogonidia; Microgonidia: Encysting process: Phases of existence.—The multiplication of the individuals of the species of Phytozoa is provided for by the process of self-division, deduplication, or fission. This takes place according to the plan obtaining in vegetable and animal cells in general.

The cell-contents divide into two or more segments, each of which can further develope around itself a gelatinous investment, and enter on an independent existence. In *Euglena*, self-division occurs longitudinally into two portions; and the newly-developing half is of smaller size than the other, but becomes complete in all its parts before its severance is effected.

The motile cells of *Chlamydococcus* undergo fission into two or four segments (XIX. 23–26): this takes place in the protoplasmic or *primordial* cell contained within the hyaline spherical *envelope*-cell; when division is complete, the latter is ruptured, the sections escape as independent beings, each throws out around itself its envelope-cell, and in all points goes through the same cycle of development as the parent-cell. Many Monads also divide into two beings, whilst others separate into four. In the above-cited examples the fission is complete, and each segment, on detaching itself from the other, becomes an independent, free being.

But this same act of fission may proceed under different circumstances; and instead of a single organism, a colony may be formed, consisting of several individual cells united together, either permanently or only for a time, within a common envelope. These aggregate Phytozoa are especially represented in the family *Volvocineæ*.

In this second mode of fission the process is repeated a greater number of times—for instance, some 3, 4, or 5 times—the result being a higher multiple of 2, the product of the first act of scission.

Each repetition of the process of fission, from the commencement until its completion, constitutes, in Nägeli's language, a transitional generation, whilst the final repetition produces the permanent generation. For example, in *Stephanosphæra* two segments are produced by the act of fission, which represent the first generation (XIX. 45); then each of these subdivides, and so developes four portions (XIX. 40, 46)—the second generation; and, lastly, each of the four separates into two, and in that way produces eight segments —the third, and in this organism the final or *permanent* generation (XIX. 41, 42, 56).

Unlike the segments resulting from a single act of division, or, as may happen, from this act once repeated, each newly-formed primordial cell does not commonly surround itself with an envelope and enter on an isolated existence, but the whole eight or more continue to live within a common tunic, which presently expands by endosmotic action and acquires a more or less spherical figure (XIX. 56, 57, 58). Simultaneously with this expansion, the previously contiguous particles are drawn away more and more from each other, and disposed within the common envelope, after a more or less regular fashion, characteristic of the species to which they belong (XIX. 42, 58). In general, the separation of the primordial cells is not complete; bonds of union between them in their early state, when closely approximated, become drawn out, and ultimately present themselves as intercurrent threads. When this series of changes is terminated, we have before us a reproduction of the aggregate organism of which the dividing primordial cell was but an individual member. Braun has styled this variety of reproduction by fission, development by '*macrogonidia*.' It is well illustrated in *Stephanosphæra*, above cited, in *Volvox* (XX.), in *Gonium* and *Pandorina* (XIX. 35, 36, 37, and 62–66), and also in undoubted Algæ, the *Hydrodictyon* or *Water-net* for example.

But the segmentation of the cells of Phytozoa occurs in yet another form; *i.e.* the fission, instead of stopping at the third or fourth generation, proceeds still further, until 32 or 64, a hundred, a thousand and upwards of minute cell-structures are produced, technically called '*microgonidia*,' intended to perpetuate the species by their ulterior development. Although, like the 'macrogonidia,' they are formed within a common envelope, yet each cell among them does not, as in those products, enclose itself with its own tunic, and fix itself permanently within the general investment—in other words, assume at once the 'still' condition; but the whole, after entire separation from one another, become endued with vital activity, and are subsequently set free, by the dissolution or rupture of the surrounding parent-cell, as so many moving zoospores (XIX. 51). The motion of these little bodies within the original cell is of a hurrying to-and-fro or up-and-down character, and has been styled 'swarming.' On emerging from the ruptured cell, each little body is seen to have a spindle-shaped figure, terminated at its anterior clear and usually elongated extremity by two or four cilia (XIX. 52). In every essential particular these microgonidia are homologous with the motile gonidia, swarming-cells, or spores of the common Algæ, such as *Bryopsis, Codium, Achlya, Chætophora, Ulothrix, Hydrodictyon*, &c. Cohn's remarks on the formation of microgonidia in *Stephanosphæra* (*A. N. H.* 1852, x. p. 346) may elucidate this subject still further. He says, "While, in the formation of macrogonidia, the secondary cells become surrounded by a common envelope and are not free (as an entire connected family of cells arranged according to a definite law), in the mode of propagation of microgonidia the little secondary cells finally become totally separated from one another without secreting an envelope-cell; and in this way each of the eight primordial cells of the perfect *Stephanosphæra* is broken up into 32 to 64 independent, green, elliptical or spindle-shaped corpuscles, which then separate from one another, commence an independent and active motion, and fill up, in great numbers (as many as 256–512), the common parent envelope-cell (XIX. 51).... The crowding-in among each other of the microgonidia of *Stephanosphæra* presents a picture fixing the attention in the highest degree: sometimes the cellules are scattered in a few large masses—then they unite again into a knot in the middle—every moment the general aspect varies. At length the common envelope is ruptured," and they escape in masses into the water. "Their true form may then be detected readily by killing them with iodine; they are spindle-shaped and acuminated at both ends, bright green in the middle, and run out into a colourless beak at each end—on the whole not unlike young *Euglenæ*, without trace of an envelope-cell (XIX. 52)." On reaching the water their movements are most active, and then rapidly disperse out of sight. These bodies are true primordial cells, "that is, primordial utricles resembling cells, organized exclusively of coloured protoplasm, without any cell-membrane."

Upon a general survey of development by gonidia, Cohn remarks (*A. N. H.* 1852, x. p. 403)—"Abstracting the differences which may always be shown between two genera, we detect the same law of development in *Hydrodictyon* as in *Stephanosphæra*: the biciliated, less numerous macrogonidia arrange themselves into a family of cells already within the parent-cell, according to the character of the given conditions of the two genera,—the cell-family being active in the Volvocineæ and immoveable in the Protococcaceæ; while the more numerous, more actively-moving microgonidia with four cilia leave the parent-cell and enter upon a metamorphosis, the retrogradation from which to the normal type of the genus has not been observed yet here, or indeed in the microgonidia of any of the Algæ." It may be conjectured that these latter pass into a resting state, prior to any further development; for both Cohn and Braun have witnessed this change in *Chlamydococcus pluvialis*.

The formation and escape of microgonidia have been observed by many naturalists—for instance, by Weisse in *Chlorogonium*, and by Perty in each family of Phytozoa. The production of such bodies is frequently treated of as development by germs, and, no doubt, is the same phenomenon Ehrenberg represents as viviparous reproduction.

Microgonidia are not so commonly developed as macrogonidia; and indeed their formation would seem determined, at times at least, by external circumstances affecting their functions and vital activity unfavourably. Thus, Cohn (*Entw.* p. 168) narrates the circumstance of the peculiar and pretty general development of microgonidia, in *Chlamydococcus*, after a thunderstorm.

Process of Encysting: Condition of rest.—The perpetuation of Phytozoa is provided for, as before intimated, by another process, which both secures to the cells undergoing it a power of successfully resisting influences that to unprotected gonidia are destructive, and is connected with an ulterior act of development. This faculty of self-protection is called "the encysting process," since by it the cell encloses itself within an additional firm tunic, which surrounds it like a case or cyst, and transforms it into a 'still' or 'winter' spore.

The process takes place in all the Phytozoa after the same fashion: the protoplasmic covering of the gonidium or cell secretes around it a dense, firm envelope, which in general becomes raised from it all round, so as to leave a clear intervening space. On the assumption of this extra covering, cells previously motile and active enter on the 'still' condition and lose their cilia; at the same time, the character of the contents is altered, and a red colour frequently acquired. The transformation in their physical structure is accompanied by a physiological change; for in place of seeking the light, exhaling oxygen, and carrying on all the vital processes with a corresponding activity, they sink to the bottom and conceal themselves from the light. It appears, from Cohn's researches on *Protococcus*, *Gonium*, and other Phytozoa, that they become released from their imprisonment, under the influence of favourable external conditions, by the deliquescence of the rigid external sac, and sometimes by its transformation into an external mucilaginous investment, and by the breaking-up of the internal protoplasmic cell into a number of motile zoospores.

The act of encysting may proceed with macrogonidia in their 'still' condition; or it may overtake motile primordial cells, as in the case of *Euglena* and of some phases of *Protococcus*, and in such, just as in the zoospores of Algæ, prove antecedent to further acts of development by fission. Cohn implies, in his history of *Protococcus*, that microgonidia may themselves be encysted; and the same eminent observer describes the primordial cells of that plant as in some instances surrounding themselves with a firm external envelope, pushing out two cilia, and moving about for a time in a 'swarming' manner ere assuming the 'still' condition, when the cilia disappear. But, further, he shows that gonidia, furnished with a rigid external wall, proceed to develope others like themselves by self-division of their substance (XIX. 25), and that these secondary cells, each included within its own sac, go on to divide into other spores, which, however, prove not to be 'still' like their parents, nor like them encysted, but motile zoospores.

In the aggregated family Volvocineæ, some or all the primordial cells become encysted. When this takes place, their contents grow thicker, less transparent, darker, and change from green to brown and brownish, or to a yellowish red. At the same time, the intercurrent filaments disappear, the cells themselves acquire a more spherical figure, and gradually loosen themselves from the common envelope, and move slowly about within it by means of two cilia, until they at length escape by a rupture at some point (XIX. 44, 50). These encysted spores resemble Chlamydomonads, and are called 'Protoccocoid' cells or globules, from their homology with the encysted cells of *Protococcus.*

Occasionally, instead of one or several of the individual gonidia of a compound organism being encysted, the process ensues with a gonidium developed by fission into macrogonidia, and the whole mulberry or *Uvella*-like mass becomes surrounded by a rigid envelope, either pretty closely applied, or separated by an interspace.

Examples of the encysted condition will occur in the following account of the several groups of Phytozoa; it suffices at present to say that Prof. Williamson and others have pretty clearly shown that *Volvox aureus* is only the encysted or 'still' form of *V. globator*, that Cohn has discovered the cysts of *Stephanosphæra*, *Gonium*, and *Eudorina*, and Henfrey those of *Pandorina*.

The after-history of the encysted spores of Phytozoa has not yet been elucidated: we have above referred to Cohn's researches upon it; but they are too indefinite to supply any positive information. The act of *conjugation* is common with many of the lower Algæ, but has not been witnessed among the Phytozoa.

PHASES OF BEING AND ALTERNATION OF GENERATION IN PHYTOZOA.—From the preceding account of Phytozoa, it is evident that those best known exist under a considerable variety of form—in other words, present several phases of existence, or, viewed in relation with a prevailing hypothesis, exhibit an alternation of generation. The whole history of any Phytozoon is comprehended in the cycle of changes which the organism passes through; yet, under any transformation, it is the self-same being, and its existence may be said to extend from its most perfect through all intermediate phases until the like degree of perfection is again attained. As happens in alternation of generations among other organized beings, the transition may not be direct and simple, but intermediate phases may reproduce themselves, and these again develope into other forms of existence, as accessory or collateral and usually imperfect cycles.

Perhaps the metamorphoses in question are most striking in *Euglenæ*; for the contrast between the actively-moving, contractile, ever-changing being in one phase of existence, and the encysted, 'Protococcoid,' spore-like and motionless condition with a rigid unvarying outline, is so remarkable as to give colour to the hypothesis of the convertibility of animal into vegetable life, or of the transformation of animals into plants. It is not our intention at present to give illustrations of the varying phases in the life of Phytozoa involved in the process of fission, or of a duplicative multiplication under its various forms. However, other more extended instances of transformation require to be noted, as observed by various microscopists,—although, it may be, some errors have crept in, from the difficulty of tracing the relation and succession of the different phases of being.

As a very good example of the wide and varied range of existence enjoyed by most Phytozoa, we may adduce the *Protococcus pluvialis* (XIX. 20-31), of which the industry and perseverance of Prof. Cohn have obtained for us so complete an account. According to the researches of this eminent naturalist, the simple plant in question, in its motile and still conditions, assumes the form and characters of many microscopic organisms presumed to be, and described by Ehrenberg and others as, distinct existences. To quote from Cohn's memoir (*R. S.* p. 559), "We see that a single species, owing to its numerous modes of propagation, can pass through a number of very various forms of development, which have been either erroneously arranged as distinct genera, or, at least, as remaining stationary in those genera, although, in fact, only transitional stages. Thus, the 'still' *Protococcus*-cell corresponds to the common *Protococcus coccoma* (Kütz.). When the border becomes gelatinous, it resembles *P. pulcher*, and the small cells *P. minor*. The encysted motile zoospore is the genus *Gyges granulum* among the Infusoria, resembling also, on the other side, *P. turgidus* (Kütz.), and perhaps *P. versatilis* (Braun). The zoospores divided into two must be regarded as a form of *Gyges bipartitus*, or of *P. dimidiatus*. In the quadripartite zoospores, with the secondary cells arranged in one plane, we have a *Gonium*. That with eight segments corresponds to *Pandorina Morum*, and that with sixteen to *Botryocystis Volvox*. When the zoospore is divided into thirty-two segments, it is a *Uvella* or *Syncrypta*. When this form enters into the 'still' stage, it may be regarded as a form analogous to *Microhaloa protogenita*: this Algal genus is probably, speaking generally, only the product of the *Uvella*-division in the *Euglenæ* or other green forms. The naked zoospores, finally, would represent the form of a Monad, or of an *Astasia*; the caudate variety approaches that of *Bodo*. A critical and comparative consideration of the foregoing facts would therefore appear to render untenable almost all the principles which modern systematists have hitherto adopted as the basis for construction of their natural kingdoms, families, genera, and species."

Cohn (*op. cit.* pp. 541, 542) makes the following general deductions:—"1. The *Protococcus pluvialis* is a plant, subject to an alternation of generations; that is to say, the complete idea of the species is not exhibited in it until after a series of generations. The forms of development which can be possibly comprehended in the idea of the species do not in reality make themselves apparent until a series of independent successive generations has been gone through. 2. The individuals of each generation are capable of propagating themselves in new generations. The individuals of the second generation are among themselves, speaking generally, of equal value: as respects the individuals of the parent generation, they are sometimes of equal value with them, sometimes not. 3. If the secondary cells are not of equal value with the parent-cells, a series of successive generations must precede the last generation, the individuals of which are again equivalent to the first mother-cell. The number of these generations does not seem to be determinate." By equivalent, the author means such individuals or generations as correspond with each other in their essential, physiological, and organological relations, although they may differ in unessential properties, such as colour, size, internal consistence, &c. Non-equivalent are those generations which in their structure and vital relations exhibit essential differences, such as 'still' and 'motile' cells, and among these, again, their various forms, and particularly those which are derived from a different mode of propagation.

Major von Flotow (*Nova Acta Acad. Nat. Curios.* 1844, p. 413), it is right to state, remarked on the similarity of various forms of development of *Hæmatococcus* (*Protococcus*, Cohn) *pluvialis* with Infusoria, signalizing the genera *Chilomonas*, *Cryptomonas*, *Gyges*, *Chlamydomonas*, *Pandorina*, *Chætoglena*, and *Chætotyphla* of Ehrenberg's system.

Phytozoa, or structures undistinguishable from them, constitute links in the chain of still more marvellous transformations. Thus, Itzigsohn represents several in the history of the development of the Oscillatoriœ. For example (*J. M. S.* 1854, p. 189)—"The filaments of *Oscillatoria tenuis* break up into perfectly distinct joints, which, at first urceolate, soon become spherical. The minute yellowish-green gonidia thus arising gradually increase in size, become motile, and present in all respects the aspect of *Chlamydomonas*." These bodies "gradually enlarge; a red eye-point becomes visible in them;

and, presenting a thousand intermediate forms, they grow into perfect *Euglenæ*." After awhile these *Euglenæ* become encysted, and terminate in the quiescent or '*Protococcus*-condition,' and subsequently, by self-division of the contents, are resolved into motile microgonidia which escape free into the water. "If a number of these remain conjoined, and move about with a rowing kind of movement, their locomotion being governed by a common spontaneity, they represent a *Volvox*-like colony, which, perhaps, may even have been described as *Volvox* by authors. The microgonidia of the *Euglena*, like those of all the Algæ hitherto examined by me, are the motile parent-cells of extraordinarily minute spiral filaments. They are at first green, gradually becoming pellucid—exactly like the spermatospheres of *Spirogyra*, presenting a Monadiform aspect. A peculiar appearance arises when many microgonidia in such groups remain green whilst the others have already become clear as water; the mass then presents, in fact, the aspect of being composed of two kinds of animalcules. Such or similar conditions would represent several species of the supposed genus *Uvella* (*atomus*, *glaucoma*, *Bodo*, &c.). Each ultimately colourless microgonidium, then, by the dissolution of its minute gelatinous envelope, discharges a small motile spiral filament." . . . "These spiral filaments do not appear to be destined for the purposes of impregnation; for they gradually increase in length and thickness, soon exhibiting numerous spiral turns," and then exchange the *Spirilla*-like for a *Spirulina*-form. "Finally, when their motile faculty has become weakened, they affix themselves by one extremity to any larger object near (for instance, Conferva-filaments, &c.), whilst the other extremity continues to move about with a creeping motion—the peculiar Oscillatorian movement, in performing which a young filament frequently returns to the spiral. The last-described condition constitutes the *Leptothrix* of authors. The filaments now gradually become thicker; and though at first of the lightest emerald-green, they gradually assume a deeper and deeper tint. The first indications of articulation are perceptible in them, until at last a young *Oscillatoria* is again perfected."

But the remarkable metamorphoses of this *Oscillatoria* are surpassed by those of the Phytozoa of antheridia, as recounted by Prof. Hartig (*J. M. S.* 1855, p. 51): the antheridia of *Marchantia* form the subject of observation. Their Phytozoa first assume the form of Ehrenberg's genera *Spirillum* and *Vibrio*, of which the most frequent varieties met with are *Vibrio rugula* and *V. prolifera*; "after twenty-four hours most of these Vibrios and Spirilla—after forty-eight, all of them—have become disarticulated." The whole drop of water in which they float is now rendered milky and turbid by numberless globules, similar to *Monas crepusculum*, in a state of active motion; and it is an important circumstance that *Spirillum* does not originate from *Monas*, but always *Monas* from *Spirillum*. After forty-eight hours, "groups of several hundreds may frequently be seen, in which the primary active motion has ceased. Shortly afterwards a sharply-defined hyaline skin is formed round these groups, and, as it would seem, by the amalgamation or conjunction of the exterior molecules; by this means the young *Amœba* (*Proteus*) is formed. This transformation takes place pretty regularly towards the end of the third day. The original size of the *Amœba* is 1-300‴ in diameter. In the course of three or four days, it grows to about the size of 1-100‴. This species differs from the *Amœbæ* hitherto described, in the fact that the inner portion of the body which bears the granules is much smaller than a certain hyaline covering, which covering is closely attached to the hinder part of such inner portion, but extends far away from the anterior part; and, in addition to this, the progressive motion in this species originates in an alternate enlargement of the longitudinal and transverse diameters, and is so slow as to amount at the utmost to no more than 1-40''' per minute. The form of the body resembles that of *Amœba princeps* (Ehrenberg). The vesicle in the hinder part of the body, which was first described by Ehrenberg as a mouth, and afterwards as an ovarium, is also present.

"After four or five days the *Amœba* assumes a spherical shape and becomes motionless, the vesicular body expanding and contracting rapidly as before, in a manner similar to what takes place in many *Vorticellæ*. These spherical motionless *Amœbæ* are then for the most part united by a mucilage into groups of from ten to twenty. The mucilage appears to be produced by the decomposition of a cast-off external skin.

"In about a fortnight after the commencement of the experiment, a green point appears in the interior of the spherical colourless body of the *Amœba*; this point gradually increases in size until it fills up the entire hollow of the *Amœba*, and after becoming covered with a cuticle it escapes in the form of an elliptical bright green cell, 1-300''' in diameter, resembling a *Protococcus*. It exhibits a round transparent cavity, devoid of chlorophyll, corresponding in size and position to the vesicular body of the *Amœba*, and resembling at its colourless apex the motile gonidia of *Cladophora*. A few days later the elliptic or roundish cell lengthens, a formation of transverse septa commences, and the unicellular Alga becomes an articulated one.

"All these transformations of Phytozoa into *Spirilla*, *Vibriones*, *Monads*, *Amœbæ*, unicellular and articulated Algæ, may be observed not only in the detached Phytozoa, but in those which remain in the interior of the sections of the antheridia. In those antheridia of which the Phytozoa are not fully ripe, the *Amœbæ* are seen to originate in the middle of the internal mass of phytozoary cells: some of them make their way out through the softened mass of cellular tissue; but others remain in the interior of the antheridium until their development into an articulated Alga.

"Contemporaneously with *Amœba*, and often earlier, there may be seen, amidst the mass of Monads, bodies very similar in form and motion to the genus *Bodo* (*socialis*), and which increase by transverse division; they have the front end furnished with a long whip-shaped antenna or cilium similar to that of *Euglena*. At their first appearance, their motion, their change of form, and their whole exterior differ so little from the earliest states of *Amœba*, that at this period they cannot be distinguished. In these early stages they both resemble *Chlamydomonas destruens* of Ehrenberg.

"The above forms uniformly make their appearance, and always in the succession above described. It is true that other forms, such as *Uvellæ* and even *Leptomitæ* and *Periconiæ*, are sometimes met with, the germs of which may have been imported by the atmosphere during the observation; but these organisms, *which always appear singly* and after the commencement of the observation, do not interfere with the above results when we consider the immense number of the Phytozoa and their uniform and contemporaneous transformations. If about a dozen preparations are made, and if they are carefully covered with a bell-glass after each observation, and if care be taken not to extend the observations for too long a time at once, at least half of the preparations will be free from all admixture of foreign organisms."

Mr. Carter has advanced some remarkable statements respecting the development of Amœbiform and other Infusoria from the so-called 'gonidial cells' of the mucous contents of various Algæ—as *Chara*, *Nitella*, *Cladophora*, *Spirogyra*, and *Hydrodictyon*, and also of some Desmidieæ and *Eugleneæ* (*A. N. H.* 1856, xvii. p. 101). Again, he finds (p. 114) the cells of *Spirogyræ* particularly infested, during conjugation, with *Euglenæ*, which are produced with such rapidity as would lead to the conclusion that the germs from which they originate must have pre-existed in the cells in which they appear (as in the Characeæ), without interfering with their functions. "Young *Astasiæ* are also developed within the cells of *Spirogyra* to a great extent; and although they at first have almost as much polymorphism as an *Amœba*, still they retain their cilium, and after awhile assume the form and movements peculiar to *Astasia*. On one occasion I saw a large *Amœba* with a long cilium at one time assuming the form of an *Astasia*, and at another that of an *Amœba*, which thus gives the link between these two Infusoria. The cilium, however, had not the power of the filament of *Astasia*, though it occasionally became terminal."

Developments of a similar Rhizopodous character are, he goes on to say, frequent in *Euglena*:—"I was led to notice this development by an apparent metamorphosis of the cell-contents of some fixed and capsuled *Euglenæ* into granuliferous *Amœbæ*, of a pinkish colour, within the old cell of *Euglena* itself; and the presence of several such *Amœbæ* creeping about the watch-glass, while many of the cells of the *Euglenæ* (*viridis*?) were empty, or only contained a little effete matter, left no doubt in my mind as to the origin of both colour and infusorium. It was also observed in some instances, where the contents of the *Euglena* had passed into an Amœbous mass, that the latter underwent a kind of segmentation, so that several (perhaps eight) small *Amœbæ* were developed instead of one large one."

Of the nature of Phytozoa. Animal and Vegetable Characters.—The collection of organisms we have grouped together for convenience' sake, and from want of a better arrangement, under the name of *Phytozoa*, is actually so heterogeneous that no general discussion respecting the nature of them as a class is practicable, whilst, at the same time, a separation between vegetable and animal forms is equally impracticable. The remarkable phases of existence through which any one species may pass upsets all our notions based on presumed constant characters: for, as we have seen, one and the same being may at one period of its existence exhibit in a preponderating degree the vital phenomena of an animal, at another those of a plant, whence has arisen the hypothesis of the metamorphosis of plants into animals, and *vice versâ*,—an idea that has found little favour, being opposed to the prevailing belief of the fixity of nature imposed on all beings. The real fact of the case is, that we have no certain criterion between the two divisions of organic nature which can be relied on and practically resorted to in cases of difficulty, such as many of the Phytozoa present.

Some naturalists have broached the notion that the phases of existence of a presumed animal or plant, which resemble in outward aspect supposed independent species or genera, are not identical with them; so that, for instance, the animal-looking *Amœba* Hartig met with in the developmental series of Phytozoa of antheridia should not be considered really an animal *Amœba*, but merely a vegetable mass simulating one. So, again, in *Protococcus* they would deny anything but external general characters to exist in common between its forms of development and the several genera Cohn would assimilate them with. There may be some truth in this supposition—there may be real animal organisms and true vegetable coinciding in form, yet distinct in nature; but the *onus probandi* rests with those who will make this distinction.

However this may be, the advance of science has rendered it certain that some families and genera which Ehrenberg, and most observers before his era, reckoned among animals, are rightly to be numbered among plants, whilst of others, again, it must still be said their position is doubtful. Deferring at present a detailed review, we will confine ourselves to a few general observations on the nature of the several families brought together under the head of Phytozoa. The *Monadina* (XVIII.) of Ehrenberg comprise a multitude of beings differing widely among themselves, and, for the most part, not placeable with certainty either among plants or animals. Of the genus *Monas*, especially, it may be said that its species are, with few or no exceptions, mere phases of being of other organisms. Of other genera the like may be presumed, although the organisms in whose cycle of life they enter as one of the links have not been determined. Not a few are doubtless zoospores of Algæ or of microscopical Fungi.

Uvella (XVIII. 5) is, in the opinion of most authorities, a vegetable structure (see p. 134); but Cohn (*Entw.* p. 115) still seems disposed to consider it an animalcule, and represents *Anthophysa* (see p. 135), which has likewise been extensively believed to be a parasitic Alga or Fungus, to be an animal *Uvella* surmounting a branching stem. *Polytoma* is another disputed possession between zoologists and botanists: among the most recent advocates of its animal character is Schneider (see pp. 136–139).

The *Cryptomonadina* would, in the language of naturalists generally, be called 'encysted' *Monadina*, and, like this family, are divisible into true vegetable and into doubtful animal organisms, the former certainly preponderating. The next two families, *Volvocina* and *Vibrionia*, and more especially the former, may without hesitation be counted with plants, whilst the remaining one, *Astasiæa*, the majority of naturalists reckon among animalcules.

Habitats. Occurrence in masses. Colour caused by their accumulation.—By far the majority of known Phytozoa are of a freshwater habit; yet it may be that, were the search as diligent, marine species might be found in nearly equal abundance, particularly in inland and shallow seas, gulfs, or lakes affording appropriate habitats for the larger Algæ. *Monads* and *Vibrios*, *Bodos*, and the *Cyclidia* of Dujardin, are probably the most abundant and widely diffused of all created organisms,—a fact not remarkable when it is considered that those genera represent the primary or germinal stage of so many organized beings, both animals and plants. They make their appearance, in collections of water and in infusions, before all others, and, unlike most microscopical creatures, find a fitting habitat in foul or decomposing fluids as well as in sweet water. They also propagate themselves with such astonishing rapidity, that the fluid or other medium in which they occur becomes coloured by them. However, this very rapid development, and this capability of colouring the surrounding medium, are not restricted to the genera named, but are partaken by others among the Phytozoa,—for example, *Uvella*, *Astasia*, *Euglena*, and the genera of *Volvocineæ*, all of them denizens of pure water, incapable of existence in impure, stagnant, and decomposing liquids.

The colour presented by their accumulation in large numbers, varies according to the species. Thus, the *Astasia hæmatodes* and *Euglena sanguinea* give a blood-red colour to water. The *Monas* (*Vibrio*) *prodigiosa* is stated by Ehrenberg to be the cause of the blood-like spots which have made their appearance at times in bread and meal, much to the consternation and dismay of the ignorant and superstitious; and, again, the *Hæmatococcus* or the red-coloured stage of the *Hysginum* of Perty is the cause of the phenomenon of red snow. A green colour is much more frequent, and due to a larger variety of Infusorial organisms; such are *Monas bicolor, Uvella Bodo, Cryptomonas glauca, Gonium, Chlorogonium, Euglena viridis, Chlamydomonas, Pandorina, Volvox, Stephanosphæra,* and others.

Besides becoming thus obvious to common observation by their colour, many Phytozoa render themselves so by the evident masses or accumulations they form. The dust-like stratum frequently noticeable on the surface of water, or at the sheltered margins of ponds, is often composed of various genera, such as *Euglena, Chlorogonium, Pandorina,* and *Gonium,* more or less intermingled with other Infusorial beings, such as ciliated Protozoa, Desmidieæ, and Diatomeæ. The stratum at times assumes the appearance of a slimy film, at others of a frothy scum.

Moreover, the variable affinity of different genera for light will cause a film at one part of a pond to differ in its composition from that at another, when the degree of exposure of the two is different. Further, there may be a transition of colour, by the changing phase and attendant change of hue of these organisms, or by the effects of the sun's heat and light at noonday, and of the darkness of night. Hence a pond which may be coloured green in the warmth of the day, when the sun's influence brings the Phytozoa to the surface and causes their rapid development, may in the morning and evening become quite clear, owing to their settlement at the bottom.

Of the modes of obtaining the Phytozoa for examination there is nothing special to record, except it be a plan mentioned by Cohn in his account of *Stephanosphæra* (*A. N. H.* 1852, x. p. 405):—"At their stations," writes this observer, "the *Stephanosphæra*-spheres occur mingled with *Chlamydococcus*, but by no means in the abundance requisite for the investigation; and although green clouds do collect at certain points in the water wholly composed of our *Volvocineæ*, it is difficult to extract sufficient of them for examination, since they immediately start apart when touched. I succeeded in overcoming this inconvenience by a simple means, so as to bring thousands of these elegant organisms on to the object-holder at any moment. I took, namely, a flat bottle with a short narrow neck, and nearly filled it with the water containing *Stephanosphæræ*, stopped it with a cork, and then laid it horizontally, so that the cork partly dipped in the water. In a few hours almost all the *Stephanosphæræ* in the water collected on the cork, which was covered with a green coat, composed exclusively of the revolving spheres, while the rest of the water in the bottle contained only *Chlamydococcus,* and scarcely any *Stephanosphæra*; so that when I wished to examine them I had only to take out the cork, and a drop of the water adhering to it furnished me with all the stages of development of our organism simultaneously in very large numbers. After a short time the *Stephanosphæræ* had again assembled on the cork."

For a more satisfactory elucidation of the Phytozoa, of their structure and physiological action, it is necessary to enter into more detail; and since there is so much structural diversity among the several groups or tribes, this more lengthened account must be given of each tribe separately. And first—

FAMILY I.—OF THE MONADINA.

(Plate XVIII. 1–28.)

In the systematic portion of his great work, in 1838, Ehrenberg instituted the following genera of Monadina, viz. *Monas, Uvella, Polytoma, Microglena, Phacelomonas, Glenomorum, Doxococcus, Chilomonas,* and *Bodo*. Subsequent researches led him to add the genus *Chloraster,* and to remove *Polytoma* in order to unite it with a newly discovered genus, named by him *Spondylomorum,* in a distinct family, the *Hydromorina*. This family, however, deserves no special consideration, but will fall within the compass of our general remarks on the Monadina, as will also the genus *Anthophysa,* in accordance with the results of Cohn's researches. (See Part II., Systematic History of Monadina.)

Very little observation and reflection will soon convince the student that the members of this group of beings can be distinguished by no such constant definite characters as suffice to establish genera and species with any precision; their history is too imperfectly known, and their individuality is unproved. If they make their appearance in a fluid, it is only transitory; for they are soon replaced by a different series of existences, and direct observation has shown many of them to be no other than transitional phases of life of other organisms. Thus, Dujardin advances as an apology for his attempted classification of Monadina, that the generic distinctions he has essayed to make "are entirely artificial, and simply intended to facilitate the naming of Infusoria which may have been met with in any particular infusion, but which, when better known, may prove in some instances mere varieties of one and the same species" (*Hist. Infus.* p. 273). Siebold entirely rejects this family of Monadina from the Infusoria, believing them only embryonic forms, and chiefly zoospores of Confervæ, &c. (*Anat. d. wirbellos. Thiere*, 1848, p. 8). In so doing he has had many approvers,—among them the eminent naturalist M. Agassiz, who thus writes:—"Recent investigations upon the so-called Anentera have satisfactorily shown, in my opinion and in that of most competent observers, that this type of Ehrenberg's Polygastrica, without gastric cavities and without alimentary tube, are really plants belonging to the order of Algæ in the widest extension of this group, while most of the *Monas* tribe are merely moveable germs of various kinds of other Algæ" (*A. N. H.* 1850, vi. p. 156). Nevertheless the character of this treatise renders it necessary for us to present Ehrenberg's views of organization. According to these, "the Monadina are illoricated, with a homogeneous body, and no external appendages except cilia, having many separate gastric sacs or vesicles, but no alimentary canal connecting them, and a bisexual or hermaphrodite propagative system. They multiply by simple and complete self-division of the body into two, four, or more individuals. The uniformity or unvarying external form may be considered one of the principal characteristics of the family; for no one of the Monadina can voluntarily alter the shape of its body, nor can it extend any portion of it and then contract it again. Propagation by ova is assumed of all the Monadina, and by living young, or viviparous reproduction, in *Monas vivipara*. Some of them have an eye-speck, but no vascular or respiratory system is discernible."

Although the general characters of the Monads are rightly delineated in this account, yet the peculiar hypothesis implied will not at the present day find supporters. Dujardin denied the presence of an enveloping skin or integument; and if a separable distinct tunic is intended, that naturalist is in the right; yet it would be an error to ignore the existence of a layer of different consistence to the contained matter, *i. e.* of a pellicle. Besides such a pellicle, some Monads, at least, have the power of secreting around themselves a second external envelope or cyst, or of 'encysting' themselves. When thus transformed, Ehrenberg would not recognize them as Monadina, but as *Cryptomonadina*, or loricated *Monadina*. Hence one source of error in his distribution of these minute microscopical forms.

The invariability of form and incapability of extending and retracting the body, so prominently advanced as special features of Monadina, Dujardin does not admit as facts, but, on the contrary, states them to be without integument, and susceptible of adhesion to one another or to foreign particles, and to be capable of stretching themselves out so as to alter their form, even so far as to produce an expansion which may at times be mistaken for another filament. Some Monadina, he adds, can, while freely swimming about, change their form, and by so doing approach the character of *Amœbæ*.

This power of the Monadina to become polymorphic is likewise alluded to by Mr. Carter (*A. N. H.* 1856, vol. xviii. p. 122).

According to modern phraseology, we might describe these beings as composed of protoplasm enveloped by a pellicle, and as having an extension of the protoplasmic mass developed in the form of a flagelliform filament, to serve as a locomotive organ. The presumed gastric cells are the vacuoles in the protoplasm hollowed out spontaneously within it, and ever changing in position and magnitude. Dujardin affirms that they at times form near the surface, open externally, and on again closing up include foreign particles which have found their way within them, and that they thus act in some measure as instruments of nutrition in aid of the general process carried on by endosmose or absorption.

That the Monadina had a mouth communicating with the 'gastric sacs,' Ehrenberg believed to be demonstrated by the introduction of particles of colour within those cavities from without. "The nutritive apparatus," he tells us, "may be readily seen in some species in their ordinary state (for instance, in *Monas guttula* and *M. vivipara*), whilst in others it is proved by using coloured food (for example, in *Monas Termo* and *M. socialis*). It consists of several distinct or separate cells (from 8 to 20), not all filled at the same time, but one after the other. These are always invisible when empty, but when filled with limpid fluid appear like so many lucid vesicles." Cohn states that he can confirm the accuracy of Ehrenberg's observation of the entrance of colouring particles into some Monads, and therefore inclines to the belief that such examples must have an oral aperture, and be of an animal nature (*Entw.* p. 162). To this he adds that many of the Monads of Ehrenberg may really be swarm-spores of microscopic Fungi; still he holds it to be improbable that true plant-cells should take up within them indigo-particles. So, at p. 148, when remarking on the precise similarity in all visible features of the swarm-spores of *Achlya prolifera* with *Trichodina grandinella* and *Bodo saltans*, he says Ehrenberg's *Bodo* eats indigo-particles, which is not the case with the form in question.

What weight should be attached to these observations of the reception of molecules of colour within Monadina, as proving a mouth and stomach-cells, must be decided by further experiments. Sometimes, possibly enough, when the minuteness of the objects concerned is remembered, the colour-grains have not actually been within, but above or below them, on the surface; and, again, other experimenters damage the force of the argument by affirming that they have succeeded in getting colour taken up by Diatomeæ, and by undoubted vegetable-cells. This statement has been made, among others, by Braun.

After the consideration given in a previous page to the nature of the supposed eye-specks, further reference to them here is uncalled for.

Concerning the modes of multiplication, the great Berlin micrographer is correct in his account of the process of fission; yet few will join with him in describing ova and viviparous reproduction among Monadina, or in imagining distinct male and female generative organs—in other words, an hermaphrodite (monœcious) structure. Certainly the phenomenon Weisse witnessed in *Chlorogonium euchlorum*, of the development and subsequent discharge of a host of young germs, might be termed viviparous reproduction; but it is no other than the usual plan of development of microgonidia among Algæ. In fact, no one has witnessed the development and extrusion of germinal ova, although the breaking up of the substance of Monadina into minute particles, by the process of diffluence or by often-repeated fission, and the reproduction of gonidia may be constantly noticed. Perty so far countenances Ehrenberg's views as to affirm the development of *Monas vivipara* and of *M. Lens* by germs which, whilst still within the parent-cell, exhibit an oscillating movement. He would even extend the phenomenon to all Monads; yet we regard it as no other than that of gonidial development. Another circumstance this same writer points out is, that in *Monas Lens* and allied forms, the anterior individual produced by transverse self-division is 3 to 4 times smaller than the posterior, and that in *Tetramitus rostratus*, where longitudinal fission prevails, the right segment is much less than the left. It is this unequal segmentation of Monads which induced Dujardin to represent their multiplication to occur by the detachment of a lobe or of an expansion, and not by actual self-division: but in our opinion such a distinction is too refined; for the term self-division has a meaning wide enough to embrace the phenomenon of fission whether by equal or unequal segments; indeed the latter variety is sufficiently common where no difficulty is felt in reckoning it a mode of self-fission.

In further elucidation of this act of segmentation in Monadina, we may add the following remarks from Schneider (*A. N. H.* 1854, xiv. p. 327–328). Speaking of *Chilomonas Paramecium*, this author writes—"Whatever number of these animals may be observed, no trace of division will ever be remarked in them. Very rarely we may see two individuals adhering by their middle, evidently produced by a longitudinal division. We shall endeavour to explain this. On close examination, one or two reddish lines may be seen running backwards from the bottom of the indentation, which might readily be taken for organs lying in the interior of the body. I have convinced myself, however, especially by the comparison of the process of division in a species of *Bodo*, that these lines indicate furrows, which gradually divide the whole by cutting deeper and deeper on each side. As during this process the animal undergoes no change of form, except in becoming a little broader, and the division takes place along its whole length, the process must readily escape observation. The anterior end is always a little thicker; the furrows consequently are deeper and more distinctly recognizable in that part. With a suitable arrangement of the microscope, it is evident that, the two furrows being looked at simultaneously, two reddish lines are seen. It is only in rare cases, when the division has taken place more slowly in some particular spot, that the two specimens must endeavour to tear themselves free, and thus, by twisting in contrary directions, draw our attention to them. That the process of division is effected in a similar manner in other Monadina, appears from an observation of Ehrenberg's upon *Cryptomonas cylindrica* (p. 42):—'I saw no instance of constriction or fissation; but two individuals were swimming whilst adhering together, which might lead one to suppose that a longitudinal division from behind forwards had taken place.' And it is not improbable that the specimen represented by him on tab. II. fig. xix. 2, with two seminal glands (nuclei?) and two longitudinal lines, was in the act of division."

That Monads are only the first and simplest stage of existence of numerous animal and vegetable organisms, is an undoubted fact; but, if we may credit some observers, their transformations are, in certain cases, very extraordinary. Thus, Stein represents the nucleus of encysted *Vorticellæ* to break up into Monads (the *Monas colpoda* or *M. scintillans*), which by various intermediate stages become reconverted into *Vorticellæ*. So, again, Hartig (*J. M. S.* 1855, p. 52) and Carter (*A. N. H.* 1856, xviii. p. 122) represent the conversion of Monads into *Amœbæ*, the former by a coalescence of a group, the latter by the simple assumption by individual Monads, on losing their cilia, of polymorphism. Lastly, the resemblance of the zoospores of *Achlya* to *Bodo saltans* has already been mentioned to be complete in every respect, save in the non-imbibition of colouring particles.

Few details, excepting those comprehended in attempted generic and specific characters, have been published by observers on the genera of *Monadina* in general. *Uvella, Anthophysa*, and *Polytoma* have, however, received more attention than the rest; and the results arrived at we will here abstract.

Uvella is, in the system of Ehrenberg, characterized by the aggregation of numerous Monads (XVIII. 3), severally undistinguishable from simple isolated species (XVIII. 4), into spherical or mulberry-like masses, freely moveable in the surrounding liquid. The individuals, like those of the genus *Monas*, have a locomotive organ, consisting perhaps of two cilia, situated close to the mouth at the anterior extremity, but neither tail nor eye-speck. They progress in the direction of the longer axis of the body, and are capable of complete self-division. In the best-examined species, *U. glaucoma*, Ehrenberg represented large internal vesicles, a double filiform proboscis, and a great number of small colourless granules, conceived to be ova, lying between the nutritive sacs. He supposed it to propagate both by transverse and longitudinal self-fission, and stated that, on feeding it with indigo, as many as twelve stomachs were filled, and that sometimes little blue particles like undigested matter might be seen voided from its mouth, and, lastly, that he had discerned several green Monads within its body, which it had eaten, and which proved it to subsist on prey directly transmitted into its interior. Individual Monads, he added, can detach themselves from the mass, live apart for a time, and again become members of the colony.

This account was rejected by Dujardin, who denied the existence of a mouth, of gastric cells, and of ova, and doubted the occurrence of true self-division. He likewise never witnessed the re-attachment into masses of the Monadiform individuals after being once separated, but believed that the reunion of certain Monads, occasionally observed in infusions rich in these beings, is a fortuitous result of the glutinous nature of their surface.

These strictures of Dujardin are, without doubt, in general very just. The supposed mouth is the clear space seen at the anterior extremity of most unicellular organisms, whilst the supposed stomach-sacs are no other than chlorophyll-vesicles or, otherwise, vacuoles. The green Monad-like cells seen by the Berlin micrographer were probably starch- or chlorophyll-cells, or, it may be, gonidia; and it was a mere assumption to represent them as swallowed particles.

Itzigsohn, Cohn, and Mr. Busk make *Uvella*, or at least an organism like it in all essential external features, a phase of existence of vegetable structures,—the first-named of *Oscillatoria* (*J. M. S.* 1854, p. 190), the second of *Protococcus*, the last of *Volvox*. Itzigsohn describes the *Euglena*-phase of *Oscillatoria* as breaking up into microgonidia which collect themselves in colonies, resembling, according to the presence or absence of coloured contents, *Uvella atomus, U. glauca, Bodo*, &c. Cohn's views are sufficiently represented in our remarks on *Protococcus* (see p. 124), and need not be here repeated. Busk represents the ciliated zoospores of *Volvox* (*T. M. S.* i. p. 39) as subdividing into minute ciliated cells (*i. e.* microgonidia), which "form by their aggregation a discoid body, in which the separate fusiform cells are connected together at one end, and at the other are free, and furnished each with a single cilium. In this stage these compound masses become free and swim about in the water, constituting in fact a species of the genus *Uvella*, or of *Syncrypta* of Ehrenberg." If these representations be correct, *Uvella* is but a phase of existence of *Volvocina* and of *Oscillatoria*, and probably of other plants. If this be not allowed, then the alternative remains, of supposing both a vegetable and an animal organism partaking like characters and qualities.

The genus *Anthophysa* (XXVI. 2) has been more particularly studied by Dujardin and Cohn. Ehrenberg provisionally placed it among the *Vorticellina* as a doubtful species of *Epistylis*, as he was unable to determine whether it possessed a wreath of cilia at its head or only a single filament: if the latter, he remarked, it would belong to the Monads. Müller, its discoverer, had indeed more rightly seized on its true position by associating it with *Volvox*. Dujardin subsequently made out its affinity with *Uvella*, and adopted M. Bory de St. Vincent's generic appellation for it. In this determination of its position Dujardin has the weighty support of Cohn, who has recently submitted it to careful examination. Dujardin's description is very accurate, and will serve our purpose. "It is very difficult," he writes, "to distinguish a *Uvella* from a free *Anthophysa*; but no difficulty will exist if some of the branching supports of the latter are seen in the surrounding fluid. These supports have an arborescent figure irregularly branched, are brownish at the base, but clearer and even diaphanous at the extremities of the branches, which are themselves nodular or rugged; they are secreted by the animals, and are found affixed to the sides of the vessel in which water containing these Infusoria has been but recently placed. Each group of animalcules is at first fixed on the diaphanous extremity of the branch which it has secreted (XXVI. 2); but any agitation of the liquid, or sudden shock, easily detaches it, and it then moves in a revolving manner in the liquid. This movement is the result of the simultaneous action of the flagelliform filaments with which each individual of the colony is provided. When, moreover, a group has been detached, whether accidentally or spontaneously, isolated individuals may be seen moving about precisely like Monads with a single filament. The branching support is at first soft and glutinous, but gradually acquires consistency and a brownish and horny aspect, when it seems no longer to participate in the life of the animalcules, and recalls to the mind the construction of the fibrous skeleton of certain sponges. It is conceivable either that the branches themselves bifurcate, or that the division is the consequence of the multiplication by fission of the groups of animalcules."

Cohn has little to add to this account. He describes the probably chitinous stem to be invested externally by a brownish mucilaginous layer; and also finds that from 2 to 8 and from that to 20 Monads may be aggregated at the extremity of the branches. Frequently a branch is bare at its point, having lost its animal colony; and it would seem that the whole of the groups are in succession thrown off and dispersed as free Monads and as Uvella-like groups. Cohn, indeed, intimates his belief that *Uvella* and *Anthophysa* are not actually distinct genera, but mere representatives of two conditions of the same animalcule. Unlike Ehrenberg, he failed to get indigo-particles taken up by the Uvella-like beings.

Before arriving at the conclusion that *Anthophysa* is no other than *Uvella Uva* seated on a branching stem, and of animal nature, he canvasses the question if this organism be not rather the mycelium of a Fungus bearing its spores at the extremities of its branches, and decides against the supposition chiefly from the irregular and indefinite multiplication of the monadiform members of the groups, from the detachment of these *en masse* instead of by separate spores, and from the want of evidence to show that, when these Uvella-like groups are detached, they assume the quiescent or 'still' condition, and germinate into an arborescent mycelium like the parent, to develope in its turn terminal masses of spores.

The branching stem has been described by Kützing and others as a microscopical Fungus (Conferva), under the name of *Stereonema*, and several species instituted; but Cohn points out its analogy with the pedicle of *Gomphonema* and other Diatomeæ, in which both the branched stem and the beings it supports are alike part and parcel of the same organic structure. He has met with fibres supporting but one or two Uvella-bundles, and others like little trees bearing ten such. The consistence of the stem is such that it resists the action both of sulphuric acid and of solution of potash.

One other genus of *Monadina*, viz. *Polytoma* (XVIII. 5), has received special attention from Schneider, Cohn, and Perty; it nevertheless still remains in that neutral ground claimed both by zoologists and botanists. Ehrenberg at first placed it in the family Monadina; but having subsequently met with a similar form, *Spondylomorum*, he instituted a new family, *Hydromorina*, to include the two genera, and set forth as its chief differential characters the aggregate or compound nature of its members, dependent on imperfect fission. He asserted also that individuals set free from the groups enter on the same cycle of fission and compound development, and form similar groups. *Polytoma* was described to be destitute of an eye-speck, to have a truncated mouth and a delicate double flagelliform proboscis, and, from repeated incomplete self-division, to form a mulberry-like mass, which eventually breaks up into isolated Monads. "The ova," he adds, "from their minuteness and the want of transparency, have hitherto eluded observation (XVIII. 5): but the alimentary organization is, on the contrary, clearly demonstrable; for although for a long time the entrance of coloured food could not be displayed, yet at length, by using a magnifying power of 600 to 800 diameters, the entrance of indigo-particles into their bodies was rendered evident." In addition to these structures, he mentions a large contractile vesicle as a male sexual organ, and a white spot at the anterior part of the body as a seminal gland. In all essential particulars the associated genus *Spondylomorum* was stated to agree with it, except in having a dorsal eye-speck.

Dujardin confesses his inability to distinguish by any definite characters between *Uvella* and *Polytoma*; he would seem, however, not to have personally investigated the latter. Cohn, after examining both, declares them to be identical in all particulars except that in *Polytoma* chlorophyll is absent, and that it inhabits decomposing fluids along with *Chlamydomonas pulvisculus*. However, it is to Schneider that we are indebted for the most complete history of this organism (Inaugural Dissertation, "*Symbolæ ad Infusorium historiam naturalem*," Berlin, 1853, translated in *A. N. H.* 1854, xiv. p. 321). We extract the following copious details from the translation:—"*Polytoma Uvella* is of an oval form; it is from $\frac{1}{200}$th to $\frac{1}{40}$th of an inch long, and about half that width. At one end, which, with Ehrenberg, we will call the anterior extremity, it bears two filaments as long or longer than the body. When the living animal is examined under a magnifying power of 300 diameters, the body appears to be bounded by a simple outline. But in many instances, and especially when a large specimen can be found at rest, it may be seen that the internal substance of the body is surrounded by a thin and perfectly clear membrane, from which it is separated by a distinct space. When the investing membrane is more closely attached, its existence may always be demonstrated by the employment of reagents to produce the contraction of the substance of the body: chromic acid and solution of iodine in chloride of zinc are the best substances to employ, the latter especially, as it at the same time communicates a brown colour to the internal sac (Pl. XX. fig. 2). Under certain circumstances, the investing membrane divides into minute granules, assuming when viewed from the side a regular necklace-like appearance (fig. 8). A reproduction of the membrane then takes place. The substance of the body is perfectly clear, with the same refractive properties as that of *Amœba*. About the middle lies a clear globular nucleus, surrounded by a narrow reddish halo (figs. 1, 2, 3, 8). Dilute acids render this more distinct. At the anterior extremity, close to the margin, there are two reddish vesicles, the contractions of which may easily be recognized in individuals in a state of repose. The hinder extremity always contains a mass of granules with dark outlines, which are not altered by acetic acid. A weak solution of iodine in iodide of potassium gives them a deep blue colour, generally verging upon black, as it is difficult to hit the right quantity of the reagent to be added. The fine blue colour is better attained by the addition of dilute solution of iodine in chloride of zinc, as with this the granules become slightly liquefied, and when left standing for some time even form a blue paste. Muriatic and sulphuric acids also dissolve them, so that the subsequent addition of iodine gives the whole body a blue colour. When the putrefaction of the infusion is going on very rapidly, the granules fill the entire body. They are not arranged in balls like the nutritive matter in the bodies of other Infusoria; and it is by no means probable that they are taken in from the exterior. Besides the two contractile vesicles, single, non-contractile, reddish vacuoles are seen scattered through the substance of the body.

"The starch-like granules are often converted into an indigo-blue pigment, which is then partially dissolved, and colours the whole parenchyma. Such specimens as these still retain the power of division, so that there can be no doubt as to their identity with *Polytoma Uvella*. Individuals were also frequently met with of which the substance of the body was of a uniform green colour, but which in other respects agreed exactly with *Polytoma*.

"Deviations from this normal form never occur singly in the same vessel, but always make their appearance simultaneously in a great number of individuals. Certain peculiarities of their abode appear therefore to have an influence upon the form. Very compressed forms are rare. However, it not unfrequently happens that, whilst the investing membrane retains its normal form, the substance of the body is not equally distributed in its interior. Sometimes it lies to one side, so as to fill only half the interior of the sac; sometimes it is entirely collected in the anterior, and sometimes in the posterior extremity; in the latter case it is connected with the anterior extremity by a slender filament (fig. 14). In infusions in which fermentation has long ceased, and which contain a large quantity of brown humus-like matter but very small portions of nitrogenous substances in solution, the two last modifications of the parenchyma are most frequently met with. At the same time the starch-like granules disappear, the substance of the body acquires a darker fatty outline, and finally disappears with formation of the well-known large vacuoles.

"The movements of *Polytoma* are the same as those usually ascribed to organisms furnished with two filaments. Whilst in motion the filaments are always in front, the animal rotates upon its axis, and this again describes circular vibrations upon a central point. If a movement in the opposite direction is taking place, the animal is endeavouring to turn the anterior extremity; and until this is effected it swims backwards. When a drop of the infusion has been left for a few minutes upon a glass plate covered over with a piece of thin glass, a considerable number of the animals will be found attached to both glasses by their anterior extremity; the filaments are free, and it is probably by their vibration that the hinder extremity is made to oscillate in the direction of the plane of the two filaments. They collect in the same manner in crowds upon aquatic plants, as well as upon the sides of the vessel containing them. Their mode of attachment is still unintelligible to me. In any case, some contrivance for this purpose, however simple, must exist, either between the two filaments, or at the side of their points of issue from the membrane.

"During the swarming-state, a division of the substance of the body goes on uninterruptedly at all hours of the day. The different stages of this process follow one another with greater or less rapidity in proportion as the conditions of nutrition are more or less favourable. Soon after the commencement of fermentation in an infusion, the rate of increase attains its maximum; it then diminishes as the fermentation ceases, the offspring at the same time undergoing a diminution of size.

"The commencement of the process of division is indicated by the uniform distribution of the granular substance. A constriction of the substance then takes place, usually commencing on one side; by this the body is divided into two parts, which are still enclosed in the uninjured investing membrane. Simultaneously with, or perhaps before the completion of this bisection, the nucleus also divides (fig. 3). Although no constriction of the nucleus was ever noticed, nothing certainly was observed to contradict the supposition that the second nucleus was produced in this manner. The two halves then become constricted from their surfaces of contact, in such a manner that the constriction of one half crosses that of the other at right angles (fig. 4). To every depression thus produced on the one side there is a corresponding elevation of the other. The quadrisection (figs. 9, 12) then takes place suddenly as if by cutting, and without any appearance of a circular constriction, each portion containing its proper nucleus. The divisions now acquire an oval form, and arrange themselves in such a manner that the ends of the posterior pair, which are turned towards the middle, alternate with those of the anterior pair in the same place (fig. 12). In very favourable circumstances (as for instance at the commencement of fermentation), a third division into eight parts takes place, each division being still furnished with a nucleus. As a general rule, however, the young individuals acquire filaments soon after the quadrisection, and move about in various directions within the investing membrane, until this bursts and the young, which are exactly like the mother except in their smaller size, are set free. In favourable circumstances the empty membrane remains with the two filaments. After the division of the substance into four or eight parts, the investing membrane is always visible without the employment of any reagents. This has not escaped Ehrenberg (*loc. cit.* and tab. I. xxxii.); he explains the appearance as a consequence of a superficial constriction. The filaments of the parent always appear to be connected only with one of the young individuals, although this is less distinguishable in the present mode of division than in that about to be described.

"In this the quadrisection takes place in another manner. After bisection, the two portions shift their position in such a manner that the surfaces of contact form a distinct angle with their original position. If this change of position be but trifling, the quadrisection goes forward nearly in the manner just described, and the arrangement of the developed young only differs as far as is rendered necessary by this change of position (figs. 9, 12). But if it be more considerable, the new surfaces of division run parallel to each other and nearly perpendicular to the surfaces of contact of the two halves. The position of the young individuals is then completely different from that seen in the preceding case; all four lie parallel to each other, with their longitudinal axis oblique as regards the axis of the whole (fig. 10).

"This difference may perhaps be explained as follows:—Each portion has a tendency to acquire an oval form, so that soon after the bisection the anterior portion extends itself posteriorly, and the posterior towards the front. When sufficient time has not elapsed for the one dimension to predominate over the other, the quadrisection takes place as in the former case; but when, on the other hand, one dimension has become predominant, the division into four takes place in accordance with the same law as the original division into two.

"The method of division first described is always met with in the early periods of an infusion, which are most favourable to the development of the creatures. Towards the end the latter mode alone occurs. This phenomenon was so remarkable that, on the first occasion of my examining an infusion towards the close of its action, I imagined that I had at first misunderstood the mode of division.

"Under certain circumstances the individuals pass to a state of rest. They are then completely filled with the starch-like granules, so that the nucleus only appears as a reddish spot. The substance of the body becomes spherical, and invests itself with a membrane which is frequently of considerable thickness (fig. 7). In this state I have never observed them to undergo any division or any other change; and when dried the cysts still retain their contents. When clear water is poured over them they do not return to life, but would probably do so in a fermenting infusion.

"The mode in which the swarming individuals arrive at this state of repose appears to be as follows:—The filaments are gradually shortened, their substance collecting at the free extremity in the form of a small knob, until at last the filiform portion entirely disappears, and, in place of the filaments, two vesicles are seen at the anterior extremity of the investing membrane. I have observed a similar contractibility of the substance of the filaments in a *Bodo* which is most nearly allied to *Bodo grandis*, Ehrbg. As this possesses not three filaments only, as seen by Focke (*Ehr.* p. 34), but often as many as five, the vesicles produced in this manner cannot easily be overlooked. I cannot, however, state with certainty whether all the individuals which undergo this change invest themselves with cysts. When infusions containing *Polytoma* are dried slowly, individuals with the vesicles just described are found in the deposit, but no cysts; and it is not impossible that such individuals may assist in the continuation of the species in some other way."

After some valuable notes on other Infusoria, Schneider concludes his history of *Polytoma* by the following arguments for its animal nature:—

"That *Polytoma* is an animal may be maintained upon two grounds.

"1. *The constitution of the investing membrane.*—As soon as the starch-like granules have been destroyed by the long action of concentrated sulphuric acid, no part of the creature is coloured blue by iodine. Now we have no more reason for believing that the vegetable cell-membrane *must* necessarily consist of cellulose, than that the animal cell-membrane should *not* consist of that substance, so that we are still compelled to seek for other characters for their distinction. These would be—

"2. *The contractile spaces.*—A statement of Cohn has certainly rendered it doubtful whether the occurrence of these is henceforward to be regarded as an essential indication of an animal nature. He says, 'On the other hand, certain genera of Algæ exhibit a stage of development in which, in external form, in the absence of a cellulose membrane, in the distinct existence of ciliary organs of motion, red eye-like spots, vacuoles, and, according to a very recent discovery, *of internal pulsating spaces*, they undoubtedly appear very similar to the Astomatous Infusoria.' If these pulsating spaces occur only in unicellular Algæ provided with cilia, these perhaps should properly be restored to their place amongst animals, notwithstanding the subsequent appearance of cellulose-membrane upon them. But if they occur in the swarm-cells of the Confervæ, they certainly cease to be a characteristic of animal nature. Thus, if we are not yet in a position to refer *Polytoma* with perfect certainty to its proper place, there is decidedly no reason for excluding it from the animal kingdom. We will not, however, venture to consider the Infusoria furnished with a mouth (*Stomatoda*, Von Siebold) as formed, like *Polytoma*, upon the type of a simple cell: for, high as we may rate the advantage accruing to science from the comparison of the Protozoa with simple cells, difficulties stand in the way of its complete application in the case of animals of such complicated structure as the *Vorticellæ* for example; and these cannot be considered as entirely done away with until the history of their development has furnished proof that at no period does a fusion of several cells take place.

"In conclusion, we bring together the results of the investigation as shortly as possible.

"1. *Polytoma* is an animal.

"2. It is characterized by a clear investing membrane, which does not consist of cellulose; two contractile spaces in the substance of the body; a nucleus with a nucleolus; two filaments; and by the deposition of layers of starch-like granules.

"3. The starch-granules may become converted into a blue or green colouring matter.

"4. *Polytoma* divides within the investing membrane into two, four, or eight parts, and propagates itself in this manner.

"5. It passes into a state of repose."

These arguments will, we fear, not be deemed satisfactory to most naturalists. That the investing membrane should not be coloured blue by iodine is an unimportant fact in determining its nature; for the same thing happens with many undoubted vegetable tissues, and we are, besides, not sufficiently acquainted with the chemical history of starch, cellulose, and allied isomeric substances, to appeal to their presence or absence as decisive of an animal or vegetable nature. Then, again, as to the contractile spaces, these cannot be considered peculiar to animal life, seeing that they are present in such generally recognized vegetable forms as *Chlamydomonas*, *Gonium*, and *Volvox*.

Moreover, Schneider himself describes starch-granules and chlorophyll-vesicles within *Polytoma*, which, if these substances had any decisive bearing on the question, would quite settle its affinity with plants, irrespective of the constitution of the enveloping membrane. Besides, the whole history of the organism accords so closely with the known phenomena of life and development of the simplest plants, that this alone must carry much weight in fixing its position in the scale of beings.

FAMILY II.—CRYPTOMONADINA.

(Plates XVIII. 29—34.)

The Cryptomonadina, which follow the Monadina in the arrangement of Ehrenberg, claim but a brief consideration, inasmuch as so little precise information is obtainable with respect to them, and as the existence of possibly all of them as independent organisms is a matter of much uncertainty. The genera enumerated were—*Cryptomonas, Ophidomonas, Urocentrum, Lagenella, Cryptoglena,* and *Trachelomonas*. To characterize the Cryptomonadina in two words, they are encysted Monadina or Euglenæ. Ehrenberg puts forward the following account:—"They exhibit all the characteristics of the Monadina, but have, in addition, an external diaphanous membrane or lorica, which either encloses them entirely—*i. e.* forms an *urceolus*,—or leaves one side exposed, and so constitutes merely a shield—*scutellum*. Locomotive organs, in the shape of two delicate filiform and generally retractile filaments or proboscides, extend from the margin of the mouth in all the genera except *Lagenella*, in which also, by the way, Werneck thinks he has discerned them. Coloured food has not been known to be received; and hence the nutritive organization has not been demonstrated: however, in six or seven species (nearly one-half the family) internal gastric cells have been discovered. In two genera sensation is exhibited by the presence of a coloured spot or ocellus at the fore part of the body. Multiplication by complete division has been seen in some specimens."

Such is Ehrenberg's account of Cryptomonadina. Dujardin has a parallel family with it he names Thecamonadina, and details the following particulars (*op. cit.* p. 323):—"The Infusoria of this family having in some measure merely one negative character in common, viz. the non-contractility of their integument, can be divided into several families according to the nature of the enclosing membrane and the number and disposition of their locomotive filaments. Thus, some are globular and others leaf-like; some have a hard, as it were stony shell, whilst others are covered only by a thin flexible membrane; some, again, have but one filament, others two similar ones or two of different size, and others, again, more than two. Until new observations have augmented the number and the knowledge of species, the differences just pointed out will merely serve to characterize genera which are indeed much more really distinct in this family than in Monadina. The Thecamonadina are in fact more advanced in organization than the Monadina; they are not, like the latter, produced in artificial infusions, nor do they change figure and characters according to the medium in which they exist. They stand in the same relation to the Monadina that the Rhizopoda (Arcellina, or Monothalamia) do to the *Amœbæ*: their organs are no more distinct; but their individuality is more pronounced."

"The Thecamonadina are all very small, although they may be rendered visible to the naked eye by their accumulation in great numbers, and by the colour they then give rise to; their colour is usually green,.... but sometimes red. They are mostly cognizable by the stiffness of their body and the uniformity of their movement." Dujardin ignores the stomach-sacs, the contractile seminal vesicle, the testis, and the green ova which Ehrenberg attributed to this family: he likewise can assign no value to the eye-specks as generic features, and is compelled to deny the occurrence of shells in the form of a shield, open on one side; for those appearing so are merely flattened on that aspect. He adds, the integument in all these cases is much more roomy than the contents, from which it is separated by a clear space having the appearance of a ring.

Perty adopts both the terms, *Cryptomonadina* and *Thecamonadina*, to express the two families under which he arranges the several genera enumerated by Ehrenberg and Dujardin, together with some instituted by himself. This is not the place to point out the distinctions he has drawn between the two families so constructed; but the original observations Perty has made on some specimens will be of interest. For instance, he says that (*op. cit.* p. 81), "When the green animalcule of *Trypemonas volvocina* (*Trachelomonas volvocina*, Ehr.) is about to self-divide, it contracts itself within its glass-like globular shell, oscillates to and fro, whilst the motor-fibres become lost, or remain without further connexion with the animal, fixed in the circular opening of the outer shell. Fission now proceeds in the usual mode into two and four individuals, which on their completion exhibit the red stigma, previously undistinguishable among the green molecules: the breaking up of the shell, scarcely $\frac{1}{1000}$th of a line in thickness, is effected either by the movements of the contained beings or by dissolution." The shells of *Trypemonas, Chonemonas,* and *Cryptomonas,* which contain no silex in their composition, seem to be particularly prone to decomposition, so that their empty shells or their fragments are extremely seldom to be met with in water abounding in loricated Monads. "In *Cryptomonas polymorpha* I have repeatedly witnessed this rapid breaking up of the shell; the margin is resolved into numerous drops which separate from one another, and in the course of ten or twelve minutes the lorica spreads itself out as an inconspicuous membranous structure. Moreover, in *Chonemonas hispida* a constant movement is observed in the shell when the animal is about to divide, and when, as almost always happens, the filaments are lost, or remain attached to the shell without any connexion with the animal. Until the period of self-division the connexion between the animal and shell persists, for the latter is, at its origin, simply the hardened periphery of the former; but when fission happens this bond is ruptured and cannot be re-established, and the contained animalcule, being thus set free, no longer moves with the shell, but in it, and this in an uneasy, irregular manner." At p. 83 he goes on to say that in *Cryptomonas polymorpha* internal germs (Blastien) are almost constantly cognizable; in smaller and young specimens in less abundance. In a pool containing *Utricularia* in July 1848, he met with the dark green variety in immense numbers, along with clear green germs from $\frac{1}{600}'''$ to $\frac{1}{400}'''$, collected in masses held together by a very delicate pellicle, and either motionless or in active movement among the old individuals. In other varieties he has seen similar germs. Thus, on pressing the large brown variety the germs escaped as independent isolated beings. In the hyaline variety (*Chilomonas Paramecium*, Ehr.) he not seldom witnessed astonishingly rapid development by longitudinal fission; in one specimen the two halves remained for a considerable time tied together by a band, which became stretched thinner and thinner by the long-continued movements of the two beings until it at length gave way. After moving about for some time, vital energy is lost, and probably one-half of the specimens sink to the bottom of the drop of fluid under observation. The germs in this hyaline variety are moreover very evident and numerous. Amid the many specimens of nearly equal and minute size, others much larger are not uncommon, furnished with a red eye-speck.

Schneider gives (*A. N. H.* 1854, xiv. p. 327) an account of *Chilomonas Paramecium*, differing much from the foregoing. He describes it as having a clear nucleus with a reddish halo around it, and, although he could distinguish no contractile space, observed a reddish vesicle always in the anterior extremity, and, in direct opposition to Perty's observations, states that whatever number of these animals he examined, he never observed multiplication by fission (p. 133).

In March 1848, Perty noticed *Anisonema acinus* (Duj.) in different stages of development; the smallest forms were evidently derived from the germs, about $\frac{1}{80}'''$ in length, and circular; by further growth they became elliptic, and presented a larger number of internal germs; at the same time the fibres, which are so easily seen in the full-grown beings, were perceived with the greatest difficulty in the smallest.

Among his Thecamonadina are enumerated two genera, named *Chonemonas* and *Trypemonas*: the latter is equivalent to Ehrenberg's genus *Trachelomonas*; but the former includes, besides *Lagenella*, two genera which the Berlin systematist placed in families far removed from his Cryptomonadina, viz. *Chætoglena*, placed among the *Peridiniæa*, and *Pantotrichum*, classed with the *Cyclidina*. Concerning the reproduction of these two genera, Perty has some original observations.

In some decomposing water he met with *Chonemonas* and *Trypemonas* in great abundance—the greater part of a green colour with red eye-specks, without lorica, and of various dimensions. In both, the lorica first made its appearance as a smooth hyaline envelope, which grew stronger, then red, and at length brown or blackish brown—becoming also in *Chonemonas* still firmer, and covered with asperities. During this transition from a soft periphery into a shell, two sets of intersecting lines were at times visible, which by-and-by vanished. Moreover, examples of *Chonemonas* occurred which continued smooth, and constituted the variety *Ch. glabra*. By using very high magnifying powers to fully developed specimens of *Trypemonas volvocina*, the lorica appeared to be everywhere perforated, or more probably beset with a series of depressions or thinner spots. On the shell becoming very dark, the green contents and the red stigma ceased nearly or quite to be visible. Naked *Chonemonads* and *Trypemonads* are easily distinguishable from *Euglenæ*, because their contractility is so much less, and consequently their actual round form so much the more permanent. All these minute naked examples are doubtless produced from germs: fission was witnessed in no instance. Ordinarily the animal-like *Chonemonas*, furnished with a red eye-speck, had an elliptical form prior to the construction of the shell, just like loricated forms; yet ovate and obovate examples are also to be seen. Minute specimens are poorer in endochrome, this material occurring only in one or two specks. The locomotive filaments are absent at first, and after their appearance only gradually attain the normal length. The construction of the lorica frequently proceeds to completion in very small specimens, whilst large ones remain naked, notwithstanding the formation of germs goes on in those where the chromule is in a certain quantity. Many dead *Chonemonads* were encountered having their contents either shrivelled up or even so completely removed as to leave only an empty yellowish-brown shell.

At a subsequent page (p. 131) Perty mentions certain abnormal forms, among others *Cryptomonas polymorpha*, having but one instead of two filaments, and at other times elongated into a tail-like process.

From all the preceding accounts of Cryptomonadina there seems sufficient to show that these beings are but a certain phase, the encysted state, of a set of organisms which have a general resemblance to zoospores, or to simple unicellular Algæ. The germs mentioned by Perty accord, to all appearance, with the microgonidia of other authors, and behave themselves in a similar manner. Cohn observes (*A. N. H.* 1852, x. p. 335)—"*Trachelomonas* and the analogous forms do not belong to the vegetable kingdom at all, but are nearest allied to the Astasiæa, and appear to be loricated Eugleneæ, not loricated Monads, as Ehrenberg assumed." We shall hereafter see that this indefatigable naturalist leans to the belief that Eugleneæ are animals; hence the idea he puts forward respecting the Trachelomonads.

As these sheets were passing through the press, Mr. Carter's valuable paper on *Eudorina* and *Cryptoglena* made its appearance (*A. N. H.* 1858, ii. p. 237). The *Cryptoglena* described is supposed to be a new species, and is named *C. lenticularis*, on account of its lenticular shape. It is compressed and emarginate, and furnished with a pair of cilia. In this little being Mr. Carter supposes an act of fecundation to take place, the microgonidia being supposed to represent the male, the macrogonidia the female element. Among the numerous specimens met with, there was a number of deciduous lorica, "some of which were split into halves which were separated, while others only adhered together anteriorly, and presented a pair of cilia attached to their point of union." In several instances, the internal cell, or the contents enclosed in their protoplasmic sac, often distended by imbibition of water to three or four times the dimensions of the germ lorica, were seen escaping from the separated segments of the latter, and in their globular shape and general features undistinguishable from *Chlamydococcus* under similar forms. These escaping internal cells were divided into two, four, eight, and sixteen parts; and it was noticed that the variety which came forth with only two gonidia was surrounded by a swarm of from ten to twenty much smaller gonidia, which were identical in all appearance with those resulting from division into sixty-four parts. But the cells divided into two segments were not the only ones so surrounded by microgonidia; for in two or three instances a few were found around and adhering to the inner cell of those divided into four gonidia.

"It was also observed that the two-division did not always come forth in one cell, but that sometimes this was also divided, so that each gonidium had its proper cell. The form of the macrogonidia or female cells did not differ from the internal cell of the parent, except in being a little smaller,—while the microgonidium, which was not more than 1-7th of the diameter of the macrogonidium, and therefore very small, appeared, though equally green, and provided with an eye-spot, to have only one cilium. I cannot help thinking, however, that, with a higher power, I might have seen two."

The purpose fulfilled by the contact of the microgonidia with the macrogonidia, Mr. Carter concludes to be that of impregnation; for he observed one of the former, as a spermatozoid, fix itself to one of the latter (the spores or female cells), and gradually become incorporated with it. The microgonidium, after having so attached itself, assumed a conical or peg-top shape, and thus appeared to gradually squeeze itself into the macrogonidium.

This mode of impregnation, thus directly observed by Mr. Carter, is the copy of that the same observer witnessed in *Eudorina* (*Pandorina*), and of that first noted by Cohn in *Volvox*. He, moreover, believes that it obtains in the case of *Trachelomonas*, for he "has often seen the largest Trachelomonad of a pool divided up into a group of apparently sixteen cells within the lorica; and this may account for the myriads of three to four smaller sizes that are frequently found together in this way. The latter certainly appear in a green form first; that is, without the lorica, which gradually becomes supplied afterwards. Thus, impregnation also in the Trachelomonads may take place like that seen in *Eudorina*, after the parent-cell has undergone division within the lorica." (See Part II., Systematic History of Cryptomonadina.)

FAMILY III.—VOLVOCINEÆ OR VOLVOCINA.

(Plates XIX. XX.)

This is the most important and most interesting family of the Phytozoa. The genera enumerated in it by Ehrenberg were *Gyges*, *Pandorina*, *Gonium*, *Syncrypta*, *Synura*, *Uroglena*, *Eudorina*, *Chlamydomonas*, *Sphærosira*, and *Volvox*. The name is derived from the rolling (*volvere*, to turn) motion of the genus *Volvox*, which is typical of the family. Ehrenberg was the first rightly to appreciate the true nature and compound structure of the principal genera as the aggregation of numerous monadiform beings in a common polypary-like mass. He correctly described the several individuals as resembling Monads in most particulars of their organization, but was so carried away beyond this simple natural statement by his peculiar views of structure, as to describe them as having an unvarying body, without other external appendages than a pair of cilia or filaments, and internally several digestive sacs but no true alimentary canal, green ova, two rounded seminal glands, a contractile (spermatic) vesicle, and eye-specks indicating the existence of sensation. The substance connecting the several beings, and in which they are imbedded, he called the lorica, and stated that propagation occurred by self-division within the envelope, and probably also by ova.

The genera *Chlamydomonas* and *Gyges*, or *Chlamydococcus* (XIX. 9-31), offer an exception to the other members of the family in not producing aggregate forms or colonies, at least not in their assumed typical phase.

Whilst denying *in toto* the elaborate animal organization presumed by Ehrenberg, M. Dujardin nevertheless continued to recognize the *Volvocina* as animal structures, and contented himself with merely proposing a different distribution of the genera. However, since this distinguished French naturalist wrote, the opinion has been powerfully advocated, and everywhere gaining ground, that the *Volvocineæ* belong to the vegetable kingdom; consequently their structure and vital phenomena receive quite a different interpretation from that given by the writers above named.

The *Volvocineæ* are now, in the language of algologists, '*Tetraspora*,' of the family *Palmelleæ* or *Palmellaceæ*. The monadiform beings are 'primordial cells,' and, in more general language, 'corpuscles,' whilst the common pellicle or nidus connecting them is called by Cohn and others the 'envelope-cell.' The author just named says (*Entw.* p. 165), that, from his observations on *Chlamydococcus*, *Chlamydomonas*, and *Stephanosphæra*, the *Volvocineæ* in general consist essentially of two parts:—1. of a colourless, hyaline, completely closed, and usually spherical envelope-cell composed of cellulose; and 2. of green primordial cells, single in the two first-named genera, but eight in number in *Stephanosphæra*, enclosed within the envelope-cell. In each case these cells are simply primordial sacs, unenclosed by any special firm cellulose membrane, and consist of a fine granular protoplasm, coloured green or red by chlorophyll, or by a peculiar oil (XIX. 48, 49). The protoplasm forms only the outer layer of the cells, and is often prolonged on the inner surface of the 'envelope-cell' in the form of delicate mucous fibres (XIX. 53). The primordial cells are moreover themselves elongated from before backwards, forming a colourless apex from which two vibratile filaments take their rise, and passing through two foramina in the envelope-cell, stretch themselves outwards in the surrounding water, and by their vibration serve to move the entire compound organism. The only difference between *Chlamydococcus* and *Stephanosphæra* is one affecting the mode of development, in which only the primordial cells (not in any way the common envelope) take part. These cells divide first into two, then into four, then into eight or more daughter-cells (macrogonidia) (XIX. 40, 41, 42); but after the third or the second, and often, indeed, after the first act of division, a permanent generation results. Thus, in *Chlamydomonas* and *Chlamydococcus*, each of the daughter-cells becomes free and independent, encloses itself within an envelope-cell of its own, and after developing two fibres, breaks through, with their aid, the common envelope of the parent-cell (XIX. 23-26 and 30). In *Stephanosphæra*, on the contrary, the eight primordial cells produced by the third act of fission secrete around themselves a common envelope (XIX. 56), which invests them like an integument, first lying close upon them, but afterwards, through the imbibition of water, raised from them all round, assuming a globular form; but so that the primordial cells occupy the periphery at the equator of the globe like a ring or zone (XIX. 57, 58), having their eight pairs of filaments protruded through the openings in the common envelope (XIX. 38). *Chlamydococcus* and *Chlamydomonas* stand in the same relation to *Stephanosphæra* that *Pleurococcus* does to *Palmella*, *Phycastrum* to *Desmidium*, *Navicula* to *Schizonema*, *Vorticella* to *Epistylis*, or as *Hydra* to *Campanularia*.

But, further, a second mode of development, viz. by microgonidia, prevails alike in the three genera in question, the bisection of the contents of the cell proceeding so far that they are eventually resolved into numberless small, mostly spindle-shaped corpuscles (XIX. 51), which at first oscillate by the aid of two or four vibratile filaments within the common envelope-cell, but subsequently escape singly from it, (XIX. 52), and, after enjoying for a considerable time very energetic infusorial movements, finally pass into a state of rest, preparatory to some future development.

"The larger undivided macrogonidia, after swarming often the whole day, are also seen to enter (as witnessed in *Chlamydococcus* and *Stephanosphæra*) into the condition of rest, when each primordial cell contained within the delicate envelope-cell secretes about itself a second more compact cellulose membrane which closely invests it, and is not perforated by the ciliary filaments (XIX. 20, 21). It is, in fact, the counterpart of the membrane which, in common plant-cells, overlies the primordial layer. In this distinctly plant-like or protococcoid condition the cells remain without motion, and may endure, even when dried, for a whole year, and then, on the addition of water, undergo segmentation into two, four, or eight gonidia, which, immediately after developing their filaments and envelope-cells, break through the walls of the parent-cell and crowd the surrounding fluid."

The facts relating to the structure and functions of the genera above adduced, apply in the main to all the *Volvocineæ*; for the differences between the several genera, although demanding special consideration, are not essential. Thus, for example, in *Gonium* (XIX. 32) the figure is a flattened spheroid, and the green primordial cells, viewed collectively from above, resemble a four-sided disc or plate, having each angle truncated. Moreover, the transparent colourless envelope does not acquire the character and appearance of a firm membrane, but presents itself as a mucous or gelatinous, not cellulose, sheath.

Chlamydomonas.—The first of the genera included by Ehrenberg in his family *Volvocina*, of which we shall attempt a description, is *Chlamidomonas* or *Chlamydomonas* (XIX. 16). It recommends itself to our attention because of its simplicity and its existence in an isolated state. This last fact seemed to Dujardin a sufficient reason for removing it from the *Volvocina* to the *Thecamonadina*, and for renaming it *Diselmis*, on account of its having two filaments; for he would admit into the former family only aggregate organisms "enclosed within a common envelope, or having special envelopes mutually adherent." On this same ground he also advocated the transposition of *Gyges* from the *Volvox* family to that of the *Thecamonadina*, a genus which we shall presently have to note under the name of *Chlamydococcus* or *Protococcus pluvialis*. To this arrangement Cohn objects (*A. N. H.* 1852, x. p. 334); for, says he, "a more profound investigation, not only of the structure, but also of the history of development, teaches us that *Chlamydomonas* (*Diselmis*, Duj.) possesses only external analogies with *Trachelomonas*, while this form, as Ehrenberg already discovered, exhibits the closest alliance to *Gonium* and *Pandorina*. The relation of the colourless envelope to the enclosed green globes, the position of the *two* cilia, which arise from the latter and pass out through the former, and lastly, the laws of division of the green cells inside the envelope, in powers of two, display themselves in exactly the same way in *Chlamydococcus* as in the rest of the *Volvocineæ*; and the only distinction between them consists in the circumstance that in *Chlamydomonas* (and *Chlamydococcus*) the individuals produced by the division of the green globes separate after the absorption of the parent envelope, and live on as individuals, while in the other *Volvocineæ* the daughter-cells produced by the division of *one* green primordial cell remain connected by the persistent parent-cell as by a common envelope, and move about as a well-defined body composed of many cells."

The best accounts of the structure of *Chlamydomonas* we have at hand are those by Perty (*op. cit.* p. 85), by Braun (*Rejuv., R. S.* p. 214), and by Thuret (*Sur les Zoospores, Ann. Sc. Nat.* xiv. 1850). Unfortunately, each of these writers describes a different species, which renders our attempt at a general history the more difficult. The figure varies between ovoid and globular; and the cell is not prolonged at the point from which the pair of vibratile filaments proceed, although a colourless space exists there. The organism consists of a green mass—the primordial cell—surrounded by a diaphanous delicate envelope, which, unlike that of *Chlamydococcus*, is closely applied to it, so that it leaves no clear interspace between the two. The contents are green globules and larger vesicles, with a single large chlorophyll-utricle in the centre—the nucleus (XIX. 16)—very like in appearance to the starch-globule so frequent in the cells of green Algæ. In addition, there is a red stigma, and in some rare instances two such; in other examples, again, it is altogether wanting. Motion is effected by the ciliary filaments, which penetrate the external envelope from the enclosed globule; the envelope resembles that of zoospores in general; and, like those structures, these unicellular beings seek the light and exhale oxygen.

Perty describes colourless germs from which new specimens originate,—a statement no doubt equivalent to saying that these beings reproduce themselves by microgonidia, as Cohn represents. Fission into macrogonidia is binary or quaternary, as in *Tetraspora*, and gives rise to two, four, eight, and even, at times, sixteen or thirty-two individuals. Generally whilst this act proceeds the cells are quiescent, ceasing from their usual movements. This process of multiplication is not influenced by the size of the Chlamydomonads, for it occurs in specimens varying between $\frac{1}{500}$ to $\frac{1}{64}'''$.

Amid the film-like collections of *Chlamydomonas*, groups of individuals may be encountered in various stages of change and of breaking up: some have entirely or partially lost their green contents; others have acquired a yellowish-brown, or, more seldom, a red colour; others are much contracted as small globules within the clear gelatinous cases, whilst others, lastly, acquire a proboscis-like process, or, by pressure, an angular outline.

The variety and transition of colour just remarked depend upon the phase of existence and the entrance on the resting or quiescent condition. The cells of *Chlamydomonas obtusa*, Braun tells us, when swarming are of a dark green colour, truncate at both ends, and, after multiplying for some time, produce here and there very minute paler and more brownish-yellow microgonidia. "In the course of a few weeks no more active cells could be found in the water, the full-grown swarms having all gradually come to rest and sunk to the bottom. The original longish shape of the cells had changed into a perfect sphere with the transition to rest; the colour of these resting-cells, originally green, gradually passed into a light yellowish brown; at the same time a number of small, sharply-defined, brilliant globules were formed in the interior, having quite the appearance of drops of oil. In this altered condition the *Chlamydomonads* remained, exhibiting neither growth nor increase." It is added, in a note, that these resting (seed) cells are about $\frac{1}{40}'''$ in diameter, have a tough, colourless, and transparent membrane, and finally assume a flesh-red colour. On awakening from this 'resting'-stage, segmentation of the contents revives, with the disappearance of the red and oil-like elements. The resting-stage of the microgonidia has not been sufficiently investigated.

Chlamydomonas Pulvisculus, in the opinion of Cohn and most others, is undistinguishable from *Polytoma Uvella* in every material point,—the absence of colour, and its habitat in decomposing infusion alone offering themselves as distinctive of the latter. Nay, what is more, he discovers the intimate resemblance of *Chlamydomonas* to the resting-stage of a *Volvox* which he discovered in decomposing infusions, and named *V. hyalina*. From these considerations he concludes that *Chlamydomonas* and *Polytoma* must be ranked with *Volvox* in the vegetable kingdom.

But *Chlamydomonas* is made to appear a metamorphic condition of yet other organisms. For instance, Itzigsohn states that, after the joints of the filaments of *Oscillaria tenuis* are separated, they produce motile gonidia "which present in all respects the aspect of Chlamydomonads, but which, after passing through many intermediate forms, grow into perfect *Euglenæ*" (*J. M. S.* 1854, p. 189). Likewise Hartig, in his account of the transformations of the *Phytozoa* of Antheridia (*J. M. S.* 1855, p. 54), makes one phase to resemble *Chlamydomonas destruens* of Ehrenberg. Lastly, Cohn confesses (*On Protococcus, R. S.* p. 555) that the motile or swarming form of *Protococcus* is scarcely distinguishable from *Chlamydomonas*, except that the latter has not been observed by him in the 'still' condition. But this presumed point of divergence itself vanishes since Braun's observations have made us acquainted with the quiescent phase of that organism (p. 147).

The relation of *Chlamydomonas* to *Stephanosphæra*, and, in general, its alliance with the *Volvocina* as a plant, have been reviewed in the preceding remarks on the family (p. 145).

Chlamydococcus (XIX. 20–31), another unicellular, isolated organism of the family *Volvocina*, has arrested much attention, and been described at large by Flotow, Braun, Cohn, Perty, and others under the additional names of *Protococcus*, *Hæmatococcus*, and *Hysginum*. Ehrenberg has no genus similarly named; but modern researches show that *Gyges* is in part its equivalent, although but one phase of its existence.

Ehrenberg's account of *Gyges* is very meagre. He characterizes it as wanting both filaments, eye, and tail, and as completely encased within its lorica (an urceolus). He could discern no traces of a nutritive system, and, except a very slight movement rendered evident by colouring the fluid, could detect no indication of animality. On the other hand, Mr. Shuttleworth examined *G. sanguineus*, and stated it to have a lively motion (*Edinb. Phil. Journ.* v. p. 29).

In our preliminary notes on the *Volvocineæ* in general, a vegetable nature is assigned to the *Chlamydococcus*; and its relation to other *Volvocineæ* is thus laid down by Cohn (*A. N. H.* 1852, x. p. 335):—

"*Chlamydococcus* is a unicellular Alga in the strictest sense of the word, never composed of more than one cell at any period of its growth, and each division forms the commencement of a new individual, whilst the remainder of the *Volvocineæ* [*i.e.* excepting *Chlamydomonas*] present themselves as families of cells, in which a definite number of equivalent cells are combined, in some measure, into an individual of a higher order.

"The researches of Alex. Braun, like my own," he continues, "have proved most distinctly that *Chlamydococcus* can only be placed with propriety among the Algæ. It is distinguished, indeed, from the moving germ-cells by which far the greater part of the species of Algæ are propagated, both by a somewhat more complex structure and by the circumstance that the motion lasts for a very long time, and, finally, by the power of the moving cells to propagate as such without entering into the state of rest (germination) otherwise than as quite a temporary condition. But these objections touch only, to some extent, the specific character of *Chlamydococcus* and the

Volvocineæ generally as unicellular plants; and they do not stand there among the Algæ altogether without intermediate conditions, as Alex. Braun has proved, especially from the long movement of the *Volvocineæ*.

"On the other hand, the external form, like the chemical and morphological organization of the contents, the laws of motion, and the general physiological phenomena, especially however the behaviour in the transition into the condition of rest, in *Chlamydococcus*, agree so perfectly with the moving spores, the transformation of which into undoubted plants has been demonstrated with scientific clearness, that no unprejudiced observer can discover an essential distinction. I have mentioned in my essay that Ehrenberg himself, although he claims the moving condition of the forms allied to *Chlamydococcus* as *Infusoria*, has declared the resting-stage of this, or a most closely allied genus, to be *an undoubted Alga*; and yet the moving Infusoria are only a propagative form of the motionless Alga. Finally, I have succeeded in *demonstrating* the membrane of the cells of *Chlamydococcus*, both in the resting *and particularly in the moving stage, to consist of cellulose*, and thus in establishing the most important criterion of a vegetable cell we are at present acquainted with—the ternary composition of the cell-membrane—in the Infusorioid condition of *Chlamydococcus*. In fact, all the more recent observers of *Chlamydococcus*, the number of whom is not inconsiderable, have, almost without exception, agreed in recognizing *in all conditions of the development of this form, only a plant and nothing but a plant*."

Besides the valuable sketch referred to, of the relations of *Chlamydococcus*, Cohn has presented an elaborate memoir on this organism under the name of *Protococcus*, in a paper translated for the Ray Society (Botanical and Physiological Memoirs, 1853), and has subsequently extended his views of it and its affinities in his essay on the development of microscopical Algæ (*Entwick. d. mikr. Algen*, 1854). Of these most important papers we shall make free use in sketching the history of this genus.

"The moving cell of *Chlamydococcus* is composed of two principal parts, a hyaline spherical *envelope*, which is formed of a delicate structureless membrane consisting of cellulose, and immediately surrounds colourless contents, perhaps consisting of pure water. In the centre of the envelope occurs a *coloured* globule, composed of the universal nitrogenous *protoplasm* or *mucus* of vegetable cells, coloured red or green by chlorophyll or a carmine-red oil, and containing imbedded in it numerous *granules of protoplasm*, as well as one or more large chlorophyll-vesicles. This coloured globule is attenuated at the upper end into a colourless point; from this go out two cilia, which protrude into the water through two orifices in the membrane of the envelope, and produce the movements of the whole. The inner coloured globule is not bounded by any rigid membrane, but merely by a thickened layer of protoplasm; hence its contour is very changeable and passes through manifold transformations in the course of its development. In particular it frequently becomes elongated in all directions into colourless radiating filaments, which keep the internal coloured globule suspended freely in the envelope, and are afterwards retracted in the course of the development.

"The motionless cells of *Chlamydococcus* are of much simpler structure, and, like all forms of *Protococcus*, consist simply of a tough spherical cellulose membrane and green or red contents organized as primordial utricle. The history of development shows that under certain conditions the contents of the motionless cells become divided into a number of portions, which always correspond to two, or a power of two, in their number, that these portions become organized into special primordial utricles, and as such break through the parent-cell, each developing two cilia, and by the aid of these rotating actively in the water. During their motion they excrete a delicate cellular membrane over their entire surface, which is gradually removed farther and farther from the primordial utricle by endosmose of water, until at length it becomes the wide envelope of the moving form described above. From this it follows that the latter forms do indeed possess on the whole the character of simple cells, but display some peculiarities in their structure and development, since the internal coloured globule corresponds originally to the primordial utricle of other vegetable cells, yet is not surrounded by a membrane, as usual, but suspended free in it like a cell-nucleus, while watery, unazotized contents appear between the membrane and the primordial utricle. For this reason I have called the enclosed coloured globule, which is formed first, and originally moves about without a special membrane in the manner of a cell, and corresponds to the primordial utricle of vegetable cells in general, the *primordial cell*, and the enclosing membrane with its watery contents the *envelope-cell*. The moving *Chlamydococcus*-condition is capable of propagating as such, by the enclosed primordial cell dividing anew, the individual portions slipping out of their envelope-cell and running through the cycle of development of their parent-cells. In passing into the state of rest, the enclosed primordial cell secretes over its surface, inside its envelope, like every primordial utricle, a new tough cellulose membrane, and through this metamorphosis assumes the form of an ordinary *Protococcus-cell*, while the envelope-cell is dissolved. But only such primordial cells behave in this way as are produced by the division of a *Chlamydococcus*-globule in a lower power of two: the primordial cells originating from a 16–64-fold division move far more actively and do not secrete an envelope-cell; they are incapable of any propagation, and pass immediately into the condition of rest. Alex. Braun has called these forms of *Chlamydococcus*, which develope an envelope-cell, *macrogonidia*, and distinguished the smaller ones originating from multifold division, as *microgonidia*."

The division of the spore- or red resting-cells of *Chlamydococcus* into two, and then into four segments, each producing a new generation of resting-cells, has of late been questioned by Cohn and Wichura; but Mr. Currey believes he can confirm this occurrence, since he has "distinctly observed the process of self-division in some red resting-cells, which were probably those of *Chlamydococcus*. I say," he writes, "*probably*, because the red resting-cells of *Chlamydococcus* are quite undistinguishable from those of another of the *Volvocineæ*, viz. *Stephanosphæra pluvialis*, so that without following out the development it is impossible to predicate whether such red cells belong to one or the other." (*J. M. S.* 1858, p. 209.) A further reference to this topic will be found in the account of *Stephanosphæra*.

On reviewing his history of *Chlamydococcus* (*Protococcus*) *pluvialis*, Cohn attributes to this plant an 'alternation of generations,' and points out the periodicity observed in the appearance in a collection of water of the several phases, the one replacing the other (*On Protococcus*, *R. S.* 1853, pp. 549, 550). Subsequently he details the number of very various and changing forms of development it passes through, "which have been either erroneously arranged as distinct genera or at least as remaining stationary in those genera, although in fact only transitional stages" (p. 559). "Thus," he continues, "the 'still' *Protococcus*-cell (XIX. 20) corresponds to the common *Protococcus coccoma* (Kg.); when the border becomes gelatinous it resembles *P. pulcher*, and the small cells *P. minor*. The encysted motile zoospores are the genus *Gyges granulum* among the Infusoria, resembling also on the other side *P. turgidus* (Kg.), and perhaps *P. versatilis* (Braun). The zoospores divided into two must be regarded as a form of *Gyges bipartitus*, or of *P. dimidiatus*. In the quadripartite zoospores with the secondary cells arranged in one plane, we have a *Gonium*. That with eight segments corresponds to *Pandorina Morum*, and that with sixteen to *Botryocystis Volvox*. When the zoospore is divided into thirty-two segments, it is a *Uvella* or *Syncrypta* (XIX. 27). When this form enters the 'still' stage, it may be regarded as a form analogous to *Microhaloa protogenita*; this Algal genus is probably, speaking generally, only the product of the *Uvella*-division in the *Euglenæ* or other green forms. The naked zoospores (XIX. 28), finally, would represent the form of a Monad or of an *Astasia* (XIX. 29); the caudate variety approaches that of a *Bodo*."

Perty has devoted several pages to recount his own observations and experiments on the genus *Chlamydococcus*, or, as he prefers to call it, *Hysginum*. He institutes two species, which he states to be equivalent to *Protococcus pluvialis* and *P. nivalis* of other authors, and insists on their specific distinctness. Probably, he adds, other varieties of *Protococcus* coloured red are also referable to this genus, at least such of them as present an animal phase of existence. To his mind, the vital phenomena of such organisms are best explicable on the supposition of an animal nature; for, says he, cells which move altogether like Infusoria, and exhibit sensation in their young condition, so long as they present such phenomena, are not vegetable cells. Moreover, he thinks it established concerning the *Phytozoa* in general, that in certain stages of their life they sometimes belong to one, and in others to another kingdom of nature, or are so nearly allied to both that a separation is impossible.

After the space already devoted to the structure of *Chlamydomonas* and *Chlamydococcus*, an abstract of Perty's long contribution on the subject cannot be introduced; and indeed, apart from his different interpretation of their vital phenomena, little could be produced not included in Cohn's complete examination. There is, however, a paragraph in Mr. Carter's just published valuable contribution on *Eudorina*, referring to *Chlamydococcus*, which must not be omitted. He writes (*A. N. H.* 1858, ii. 244): "*Chlamydococcus* undergoes the same kind of changes in development as *Eudorina*, from which it only differs in structure in being smaller and globular instead of ovoid, in the absence of an external envelope, and in the cilia of the daughter-cells being *included* within the parent-cell; hence it also differs in being motionless, though the compartments of the daughter-cells are sufficiently large for them to turn round and move their cilia freely therein, which they are continually doing. The primary cell of *Chlamydococcus*, like that of *Eudorina*, divides up into two, four, eight, or sixteen cells, and those of the eight- and sixteen-divisions again into groups of sixteen or thirty-two each, so as to resemble the third stage of *Eudorina*. Hence we may perhaps infer that its fecundating process is similar to that of *Eudorina*; but this remains to be discovered. *Chlamydococcus* has also a great tendency to stop at the two- and four-division, from which it may pass into the 'still' or *Protococcus*-form, and, floating on the water in a kind of crust, present cells of all kinds of sizes undergoing 'still' division. In all its multiplications, partial and entire, however, it generally maintains its primary or spherical form, and does not become ovoid or oblong like the groups of *Eudorina*,—the only exceptions being in the two- and four-division, where the green cells are sometimes ovate (probably from want of room in the parent capsule), as represented by Ehrenberg in *C. Pulvisculus*, to which I should refer it, had he not also given an ovate form to the type-cell of this species: nor can I refer it to *C. pluvialis*; for in all the changes I have yet seen it undergo, the red colour has not increased beyond the minute eye-spot, while this also disappears, and the cilia too, when this species passes into the 'still' form. Here it undergoes the same kind of division that it does in the active state; but the parent-cell, instead of becoming distended by imbibition, remains closely attached to the daughter-cells, so as to give the group a mulberry shape. How long it remains in the 'still' form I am ignorant; but having only seen it in the active state during the months of May, June, and August, and throughout the rest of the year in the 'still' one, I am inclined to think that it only comes into the active state during the summer months, and then for the purpose of fecundation.

"In several instances, also, where I have found this *Chlamydococcus* with *Eudorina*, they have been accompanied by long Closteriform cells. It was the case in that above mentioned, where the latter was undergoing impregnation. Some of these have an eye-spot, which, with the nature, arrangement, and general aspect of their internal contents, shows that they belong to the class of organisms with which they are associated. Their cell-wall also is more or less plastic, or was so when they were assuming this spicular form; for many have one or more *diverticula* extending from them, some are bifid, and a few irregularly stellate. What they are, I know not; but Dr. Cohn has figured the same kind of cells, in company with *Sphæroplea annulina*, under impregnation."

Mr. Currey (*op. cit.* p. 216) has noticed and figured what he conceives to be a generative variety of *Chlamydococcus* (XX. 24). "This," he says, "I take to be a state of *Chlamydococcus*. The outer membrane was colourless, and the two internal globular cells of a clear, bright ruby crimson. The peculiarity of the plant consisted in the fact of the cell being filled with minute staff-like subcylindrical bodies in active motion, precisely similar to the spermatozoa of *Vaucheria*. I watched these bodies at intervals for about twenty-four hours; and the motion was incessant. At the end of that time the cell slipped amongst some other Algæ on the same slide and was lost. Whether these little active organisms were really spermatozoa, or whether they belonged to the mysterious bodies which, in some way or another, are supposed to find their way from without into the cells of Algæ, it is impossible to say."

The next figure (XX. 25) is also copied from Mr. Currey, and, as he remarks, evidently "represents the final stage of some *Volvocineæ* in which the gonidia have become encysted." We allude to it here, although it does not belong to *Chlamydococcus*. Mr. Currey observes further, "I notice it because the encysted cells were of a pale yellowish-brown colour, and covered with minute pits or depressions, and were altogether different from those of any other Alga with which I am acquainted. In *Pandorina* and *Stephanosphæra* the resting-spores are red, in *Volvox* bright orange; and in neither case are there any such markings as those in the membrane of the cells shown in the figure referred to."

Gonium (XIX. 32–37).—This genus received considerable attention from Müller and Ehrenberg. The latter described it as composed of sixteen Monads, resembling *Chlamydomonas* in all points except in the absence of an eye-speck, collected together in a quadrangular tablet, with from three to six intercommunicating tubes or cords. Each Monad was said to be enclosed in a hyaline lorica, called here a mantle (*lacerna*), which it could at times quit; also to have two filaments (*proboscides*) extended from the mouth, represented by a clear spot at their base; several clear stomach-sacs, a contractile vesicle, two round sexual glands, and numerous green ova. Detached individuals, he added, swam like Monads, in the direction of the longitudinal axis of their bodies, with the mouth in advance; but when in tablet-like colonies sometimes moved horizontally, at others vertically, or rolled on their edges like wheels by the aid of the pair of vibratile filaments of each member projecting from the surface.

The animal organization here represented is now-a-days generally ignored, and *Gonium* takes up its position among plants. Prof. Cohn (to whom we are so much indebted for our knowledge both of Protozoa and Protophyta) has contributed a valuable paper (*Entw. d. mikr. Algen u. Pilze*) on this interesting being, of which we shall present an abstract.

The entire organism is invested by a colourless transparent muco-gelatinous envelope without any cellulose limit-membrane, whence it is that this common envelope has frequently passed unobserved unless some colouring matter, such as Indian ink, has been added to the water.

The figure varies according as the plant is viewed from above (on its polar aspect) or from its side (on its equatorial aspect), being in the former point of view a quadrilateral tablet with truncated angles and rounded corners (XIX. 32), and in the latter a flattened spheroid.

The simple or primordial cells (XIX. 33) enclosed in this mucous sheath are sixteen in number, disposed in a uniform manner, so that four cells, leaving a square interval in the centre, are bounded externally by twelve others, three of which form one of the four sides of the organism (XIX. 32). The central cell of the three is, moreover, not in a line with the other two on the same side, but set nearer to the centre; hence each side of the tablet is hollowed out in the middle. Closer research also shows that each of the cells is not spherical, but polygonal, the four internal being six-sided (hexagonal), the twelve peripheral five-sided (pentagonal); the consequence is, angular intercellular spaces are left, the central of all being quadrangular, and all the rest triangular. This arrangement of the primordial cells is normally so regular, that Cohn represents it by a geometrical diagram; still, in all tablets of *Gonium* this is not the case, and particularly in very young specimens.

The regular polygonal contour of the cells indicates that they are not mere masses of soft variable protoplasm, like those of *Stephanosphæra*, but, on the contrary, are each of them surrounded by a colourless, hyaline, delicate but firm membrane, imposing on them their fixed form (XIX. 34). This structure indeed is not generally discernible, unless by some abnormal conditions, or by the occurrence of self-division (XIX. 35), in which, as only the green contents are concerned, it comes to stand apart from the latter as a distinct, separable sac. It can, moreover, be demonstrated by crushing the cells, when the chlorophyll escapes through the rent, and leaves the colourless and fractured case. Cohn is convinced that this membrane is composed of cellulose, although, from the inability to isolate them, he has been unable to prove it by chemical reagents.

Without any preparation this investing membrane can, further, be detected at the angles of the cells, from each of which it is prolonged in the form of a short tubular process, empty and colourless, the contents being restricted to the general cavity of the cell (XIX. 34). Each cell sends out such a process from its several angles to unite with a similar one from each contiguous cell: in this way are formed the intercurrent cords or canals alluded to by Ehrenberg. It follows also from this structure that the link connecting the angles of conjoined cells, belongs one half to one and the other to its companion-cell.

The nature of the *Gonium*-cells and their connecting tubes is clearly displayed by observing the changes consequent on the gradual evaporation of the water about them. For instance, on adding salt by degrees, a portion of the water included in the cells is withdrawn, whereupon their contents contract themselves into a globular form, revealing the investing membrane in its entire periphery. Again, when the mucous envelope breaks up by diffluence, the cells show a tendency to separate: the link-like canals are first drawn out, and subsequently give way at the point of junction of the two processes which form them—and this with such a degree of elasticity, that the cells appear to burst from one another with a spring; and thus at length the entire organism is resolved into an irregular collection of cells.

In the immature period (XIX. 33–36) the outline of the cell-membrane is spherical; for the angular figure and the development of the junction-processes are subsequent phenomena. Further, the extension of the processes at times goes on so far that the *Gonium*-cells at first sight appear detached from each other and free, which is never the case naturally.

In other points of organization the cells of *Gonium* correspond with other loricated swarm-cells, particularly with those of *Chlamydomonas*. Their contents consist of protoplasm coloured by chlorophyll, among which, in older specimens, are numerous corpuscles (the ova of Ehrenberg) that impart a deeper colouring; of a central circumscribed darker corpuscle, which, as participating in every act of fission of the cell, must be esteemed a nucleus; of several vacuoles, often numerous but occasionally wanting, and of two or three sharply-defined vesicular spaces, constant in position at the base of the filaments (XIX. 33). The last-named are the locomotive organs of the organism, are two in number, and proceed from the protoplasm, passing through foramina in the special cell-wall, and afterwards through the common mucilaginous envelope, so as to appear, in the polar aspect, like outstretched fibres from the tabular organism.

The movements of *Gonium* resemble in all respects those of *Stephanosphæra* and *Chlamydococcus* and other swarm-cells. The plant revolves on its short axis, so that in its polar aspect it appears like a rotating surface, whilst in its equatorial it has on the contrary a linear outline.

In the course of its development by self-division, neither the general mucilaginous coat nor the cell-membrane is concerned, but only the contents. The fission into 16 segments to form a new colony has not that simultaneous character which Ehrenberg implies, but takes place by four stages or generations, in every one of which a bisection of each cell already developed ensues (XIX. 35). It is only in fully developed *Gonium*-tablets that self-division is effected—for example, in such as have cells $\frac{1}{200}'''$ in diameter, and separated from one another by the elongated intercommunicating processes, and where those cells have the disposition described as characteristic.

On the completion of the act of self-division by the construction of 16 small cells, these are found occupying just the same relative position within the membrane of their parent-cell as do the members of a perfect *Gonium* (XIX. 36). Amid numerous examples of the plant, specimens may be met with abnormal in the number of constituent cells; for instance, colonies of only 8 cells occur, which are explicable on the supposition that the last stage of fission, *i. e.* the last act of generation, has been arrested, and only three such acts completed. The like irregularities are often noticed in other *Volvocineæ*.

The primordial cells of the newly generated colonies appear unconnected with each other, whilst the mother-cell wall, which still includes them, is considerably distended and elongated in one direction (XIX. 30). The movement of the colony as a whole continues until the last stage of fission is completed, whereupon it ceases, and the newly formed groups commence a movement within their enclosing cell, sometimes presenting themselves in one plane as a disc formed by a collection of green globules, at others, on their edge, looking little more than a green line.

At length the mother-cell ruptures, and, the mucous envelope having disappeared at a previous stage (XIX. 37), the young colony escapes into the surrounding water, moves freely about, and commences an independent existence. These young forms have usually a diameter of $\frac{1}{100}'''$. Supposing, which is very probable, that a young *Gonium* after 24 hours is capable of development by fission, it follows that under favourable conditions a single colony may on the second day develope 16, on the third 256, on the fourth 4096, and at the end of a week 268,435,456 other organisms like itself. This calculation sufficiently explains the extremely rapid multiplication of these organisms, colouring a collection of water, floating on its surface as a scum, or settled in bad weather as a filmy stratum at the bottom.

The cells which break away from the group, and so leave vacuities in its conformation, resemble in their isolated condition the cells of *Chlamydomonas*. Such detached cells were deemed by Ehrenberg equally capable of fission as the persistent members of a colony; Cohn, however, has never observed the phenomenon, and believes, on the other hand, that, after swarming for a time, they enter into a state of rest, and by shedding their locomotive filaments assume the Protococcoid state. This 'still' form of the *Gonium*-cells is in all likelihood also entered upon when the water in which they live is dried up and the functions of life suspended; and it may be that on the addition of fresh water such cells give issue to motile forms, and thus a parallel series of changes occur in this organism to that observed in *Stephanosphæra*. Nevertheless a resting-stage of *Gonium* is not positively demonstrated; for although analogy is in favour of it, and the occurrence of Protococcoid cells in company with the ordinary tabular groups suggests the probability that these are 'still' cells, yet the absence of characters to distinguish them from the swarm-spores of other Algæ renders their determination at best a matter of doubt.

Development by fission as described is, therefore, the only mode proved to exist; it resembles that in *Chlamydococcus* and *Stephansophæra*, by which macrogonidia are formed. The production of microgonidia, as seen in both the genera just named, as well as in *Eudorina* (*Pandorina*) and *Volvox*, is as yet unknown in *Gonium*.

Respecting its relation to other *Volvocineæ*, it is to be observed that, although there are striking differences, there are, on the other hand, decided natural affinities betwixt them and *Gonium*. Thus, although the envelope-cell is so imperfectly developed that it cannot be represented as a special shut sac, as in the case of *Stephanosphæra*, *Chlamydococcus*, &c., yet it is analogous to the envelope-cell of those genera in its relation to the cell-contents; and, besides, in the case of the intimately allied *Eudorina elegans*, the common envelope, which resembles that of *Stephanosphæra*, is found first as a simple, and later as a double fine cell-membrane. (In *Pandorina*, indeed, Professor Henfrey asserts the mucous envelope to be devoid of a limiting membrane.)

Again, the primordial cells of *Gonium* are enclosed in a special membrane, and not mere globules of protoplasm unprotected save by a pellicular layer of the same substance; thus the disposition in *Gonium* (the primordial cells enclosed by a membrane, the envelope-cell not invested) is just the reverse of that in *Chlamydococcus*, *Chlamydomonas*, and *Stephanosphæra*. However, the existence of a membrane around the primordial cells is not an anomalous circumstance among the *Volvocineæ*, since, in certain stages of development, a firm closely applied membrane is produced around the cells of the other genera—as, for example, around the microgonidia of *Chlamydococcus* when they enter on their resting-stage, and about the cells of *Stephanosphæra* when preparing to leave the common envelope. But, further, in these instances, when this special closely applied membrane appears, the envelope-cell breaks up into a mucilaginous layer, and then presents the normal condition of that of *Gonium*. In other structural matters, in the number of vibratile filaments, and in the history of development, *Gonium* entirely accords with the other genera.

After this review of the affinity of *Gonium* with the other *Volvocineæ*, it follows that, like them, it must be of a vegetable nature, although cellulose has not been detected in it. Still more, the evident relation of *Gonium* with *Pediastrum* (II. 44), the plant-nature of which no one at the present day will gainsay, points to the same natural position. It agrees with that plant in general structure, in the union of several cells in one plane, in the number of those cells and in their self-fission in the power of two, in the development of new tablets and in obedience to the same laws. The only difference between these two genera is, that in *Pediastrum* the swarming of the cells, although surrounded by a common envelope-cell, ceases when they are associated together in a tabular form,—whilst in *Gonium* the reverse is seen, the power of motion becoming manifest when the several cells are in combination. To state this generally: in *Pediastrum* the individual cells swarm, and the colony is quiescent; in *Gonium* the colony swarms, and the quiescent state of the several cells follows upon their separation.

However, there are organs in *Gonium* which, did they admit of proof as essentially animal structures, would be fatal to all these arguments for its vegetable nature. These are the two, or more rarely three, permanent vacuoles visible near the origin of the vibratile filaments, which are seen to contract and expand alternately within a brief interval. These contractile vesicles have a sharp outline, are colourless, and look like clear rings in the midst of the green cells. To detect them and their movements, the most translucent and large cells must be chosen; they must also be perfectly still, and lie flat upon the glass slide,—an object attainable by a partial evaporation of the drop of water.

The two vacuoles (XIX. 33) are but little apart, equally clear and large, and apparently unconnected. Their action is alternate, each vacuole undergoing a systole and diastole in succession, whilst the time occupied by the systole, by the diastole, and by the interval is equal. The same equality in time obtains also between the two vacuoles of the same cell. Likewise a uniformity prevails among the different cells of the same *Gonium*, but not among the cells of different specimens; and Cohn holds the occurrence of rhythmical contractions of these vacuoles as a well-established fact.

These, therefore, are pulsating spaces, filling up with water, and after a time expelling it, and agree in all points with the so-called 'seminal vesicle' of Ehrenberg (the contractile sac or vesicle of other authors) met with in ciliated Infusoria. Cohn next proceeds to discuss the question if these pulsating sacs are to be considered exclusively animal organs, and arrives at the conclusion that they cannot be so considered, and cannot be appealed to in the decision of the question of the animal or vegetable nature of any doubtful organism.

To conclude this complete history of *Gonium*, as abstracted from Cohn's elaborate essay, we must add that the description applies only to *Gonium pectorale* (Ehr.), which, in the author's opinion, is the only species referable to the *Volvocineæ*, the remainder enumerated by Ehrenberg being members of the genus *Merismospedia* of the *Palmellaceæ*.

PANDORINA (XIX. 59–69; XX. 22, 23).—This genus has recently been very carefully and thoroughly examined by Prof. Henfrey (*J. M. S.* 1856, p. 49) in an able memoir, of which we shall make free use to supply our readers with a satisfactory description of this interesting and beautiful organism. The specimens examined were of the species *Pandorina Morum*, of which, as Prof. Henfrey justly remarks, the description "given by Ehrenberg is so incorrect, that no one would be able to determine the organism by its aid; but the figures in the *Infusionsthierchen*, although rude, are sufficient for identification." Dujardin contributed nothing to our knowledge of this genus, which he treated as one with *Eudorina*, objecting, very justly, to the worthlessness of the red speck as a distinctive generic character between them.

Prof. Henfrey's account is so succinct that it admits of no abridgement, we are therefore induced to present it entire. "The forms," he writes (p. 50, *op. cit.*), "presented by this organism are exceedingly varied; and nothing can be more beautiful than a number of them revolving slowly on their long axes in a drop of water, as seen under a power of about 100 diameters. In the first place, the perfect form exhibits two patterns (shown in XIX. figs. 59 and 60); and there are minute counterparts to these, remaining in that state, while, in the water where the species is actively multiplying, all sizes between fig. 64, just emerged from the parent frond, and the full-grown form, figs. 59 and 60, &c., occur. The form with 32 gonidia results from the cell-division going on one stage further than in the form with 16; but this difference is fixed during the earliest stages of development, as the form with 16 never changes into that with 32 after it has become free from the parent. In the perfect forms the gonidia are arranged near the periphery of the frond, in circles, like the equator and parallels of latitude on a globe,—so that *Pandorina* resembles Cohn's *Stephanosphæra* more closely than any of the other *Volvocineæ*, that having a single equatorial ring of gonidia in its globular frond. Among the forms with the isolated gonidia occur others almost equally numerous with the gonidia collected together into berry-like heaps (figs. 65–68): these are smaller than the others, but equally varied in dimensions; their gonidia resemble those of the other form; they appear destined to form the resting-spores.

"The gonidia are almost globular; they have no proper membrane, but consist of a gelatinous granular substance which contains a thinner fluid in the centre, as it contracts strongly by exosmosis when strong saline solutions are applied. There is a large nucleus-like body (the chlorophyll-vesicle of A. Braun) at the posterior end of the gonidium (fig. 61); and at the opposite side is a short beak-like process, with a colourless space behind it: the pair of cilia arise here; and a little to one side and below these is the reddish-brown granule called the 'eye-spot.' We have never been able to observe a pulsating vacuole, as described by Busk and Cohn in *Volvox* and *Gonium*.

"The gelatinous frond appears to be perfectly homogeneous, without any boundary membrane. Iodine and sulphuric acid do not colour it blue. It is tolerably resistent, and appears solid, as it does not give way or become indented by external pressure, as is the case with the hollow frond of *Volvox*.

"The fronds are multiplied by the conversion of the gonidia into new families. If they are viewed at night, many of the fronds may be found at rest at the bottom of the vessel (in the daytime they assemble at the side next the light), motionless, and with the gonidia rounded and deprived of their nucleus. By covering up the bottle from the light, the development of the new fronds, which naturally takes place very early in the morning, may be retarded, so as to be followed during the morning until noon. Some of the fronds may be found with the gonidia converted into berry-like heaps (fig. 62), others with the gonidia already distinct (fig. 63), while many parent fronds present the young fronds more or less regularly arranged in the softened and expanded parent mass, which ultimately dissolves and sets them free (figs. 64, 65). They then increase in size in proportion to the favourable conditions in which they are placed. I have never seen anything like what are described by Cohn in *Stephanosphæra* as 'microgonidia.' In a letter received from Professor A. Braun since the above was written, he speaks of the forms with small gonidia (fig. 64) as the 'microgonidial' form.

"When kept for some weeks, an increasing quantity of fronds became accumulated at the bottom of the water, and these chiefly of the character shown in fig. 66, but devoid of cilia; and while many of them decayed, in others the gonidia became encysted so as to form globular cellules. Left for a fortnight, the water was found without a trace of green colour, with merely a brownish sediment at the bottom, upon examining which, it was found to contain a large number of berry-like forms with the gonidia not only encysted, but with their contents converted into a red, oily, granular substance (figs. 67, 68), as in the resting-spores of many Confervoids. The gelatinous frond was here almost dissolved away; and a slight pressure was sufficient to detach and separate the cellules, which are doubtless resting-spores (fig. 69) and destined to become subsequently developed into new fronds. This remains to be decided.

"The organism thus described is a well-marked and distinct species, very different from *Volvox* and *Gonium*, but approaching near to *Stephanosphæra*. The form which produces the resting-spores, after losing its cilia, is Kützing's *Botryocystis Morum*. I have met with a form like this not unfrequently, but never before with the perfect *Pandorina*. Mr. Pollock tells me that he has collected from the same pond for some years past, but never found *Pandorina* before, and yet it colours the water green this season. *Volvox* seems, in like manner, to come and go at intervals of years, its revivification from the resting-spores depending much on external conditions."

Mr. Currey's valuable contribution to our knowledge of the British freshwater Algæ (*J. M. S.* 1858, p. 213) furnishes the following memoranda on *Pandorina*. He writes—"In speaking of the reproduction of *Pandorina*, Mr. Henfrey mentions two processes: 1. the conversion of each gonidium into a new frond within the parent mass; and 2. the conversion of the gonidia into encysted resting-spores, which are set free, and subsequently germinate to produce new fronds. Upon this I may remark, that the process of becoming encysted does not invariably take place *within* the parent frond, for I have seen the gonidia of *Pandorina* escape from the parent frond in the form of membraneless active zoospores; and although I was not fortunate enough to trace the subsequent fate of these zoospores, the probability is that, like those of *Chlamydococcus* and *Gonium*, they would become encysted at a subsequent period, as, without undergoing this process, it is difficult to see how they could produce new fronds. This mode of escape of the zoospores seems to throw some doubt upon the suggestion of Mr. Henfrey with regard to the nature of the frond of *Pandorina*, which he considers to be solid, inasmuch as it does not give way or become indented by pressure, as is the case with the hollow frond of *Volvox*. If, however, the frond were solid, the zoospores could not well escape, except by its gradual dissolution; but, in the instance I have mentioned, the escape certainly took place by a rupture (as may often be seen with *Volvox*), and not by a gradual process of dissolution. In a paper on some *Volvocineæ* by Dr. Fresenius, in the second volume of the Transactions of the Senckenberg Natural History Society, he speaks of the easy escape of the cells of *Gonium pectorale* as being evidence against the existence in that

Alga of any firm covering, and he draws a distinction in this respect between *Gonium* and *Pandorina*. My observation, however, leads me to think that *Pandorina*, as far as relates to its coat, does not substantially differ from *Volvox* and *Gonium*. Besides the nature of its coat, there are some other points of structure in *Pandorina* requiring further examination and elucidation. Ehrenberg stated that the gonidia of *Pandorina* have one cilium, and no eye-spot, a view adopted by Fresenius in the paper I have alluded to. Focke and Dr. Braun considered Ehrenberg's observations inaccurate, and Mr. Henfrey agrees with them. As far as my observations go, I should say that the gonidia have usually two cilia, but that they frequently have no eye-spot. Mr. Henfrey has never been able to observe a pulsating vacuole, nor was any such vacuole visible in my specimens. Dr. Fresenius, on the other hand, has observed one, sometimes two, such vacuoles; and he remarks that cilia and red spots are subject to considerable variation, and suggests that *Stephanosphæra* and *Volvox* are probably the only distinct forms to be met with in the *Volvocineæ*. I should protest against including *Gonium pectorale* in the same genus as *Stephanosphæra*; but, with this exception, Dr. Fresenius's suggestion is probably correct. If, however, *Stephanosphæra* and *Pandorina* are only forms of the same plant, the generic name '*Stephanosphæra*' must give place to '*Pandorina*,' the latter being of much earlier date."

According to Braun (*Rejuv.*, *R. S.* p. 21, *note*), the colonies of *Pandorina* revolve always to the right; but Prof. Henfrey corrects this statement, asserting that they change the direction constantly. Another circumstance remarked by Braun is, that both the birth of the first generation of gonidia, and the production of the succeeding generations by the division of the earlier, occur in the morning after nocturnal preparation (p. 224),—a circumstance, indeed, which prevails in all the *Volvocineæ*. We must also note that among the many phases of development of *Chlamydococcus pluvialis*, Cohn discovers two comparable in form to *Pandorina Morum* and to the *Botryocystis Volvox* of Kützing (*op. cit. R. S.* p. 559).

The late valuable contribution of Mr. Carter on *Eudorina* (*Pandorina*) (*A. N. H.* 1858, ii. p. 237) claims our especial attention as confirmatory of Cohn's discovery of the sexuality of *Volvox*, a parallel fact to that he had previously made out in the case of certain indubitable Algæ. Mr. Carter identifies the organism he has studied with the *Eudorina elegans*, Ehr., a species which naturalists at the present day refuse to consider actually distinct from *Pandorina morum*, inasmuch as the solitary character upon which the separation was made by Ehrenberg, viz. the presence of a red speck in *Eudorina*, is well known to have no pretensions to a specific, and still less therefore to a generic character. Indeed, Mr. Carter himself treats the 'eye-spot,' if not as a mere accidental feature, yet as only an adjunct of a particular phase of plant-life; for in the very paper under notice he puts forward the query, "Does not the disappearance of the eye-spot in the 'still' form thus seem to point out its analogy with the bright colours, especially the red, presented by plants in their flowers during the season of fecundation, rather than with the eye of animals?"

We may consequently regard this excellent paper by Mr. Carter as an important supplement to Prof. Henfrey's admirable and lucid memoir on *Pandorina*, especially its developmental history. At the risk of some repetition, we shall allow the author to explain his researches and opinions in his own words, and the more so as his plan of proceeding and manner of description do not tally very precisely with those observed in the preceding account of *Pandorina*.

"Before going," Mr. Carter writes, "to the fecundation, it is desirable that we should trace the development of *Eudorina* up to this point; but not having been able to recognize this organism in its simplest form (that is, as a solitary single cell), nor any stage of its *segmentation* prior to the third degree of duplicative subdivision (that is, into 16 cells, when the mother-coverings have dropped off), I must begin from this period.

"At this time, which we will call the first stage, the *Eudorina* consists of an ovoid green body, partially divided into the number of cells just mentioned, each of which is provided with a pair of cilia which project through a thin gelatinous envelope that surrounds the whole mass. It is now in its smallest size, about 5-5400ths of an inch long, that is, not more than the diameter of the *Chlamydococcus-cell*, and swims by means of its cilia, with the small end foremost, and with a rotatory motion on its longitudinal axis, as often from right to left as from left to right. An eye-spot is also present in each of the four anterior cells, but seldom visible in the rest at this period.

"As the development progresses and the *Eudorina* increases in size, the division becomes complete, and each cell, in addition to the granular mucus and chlorophyll which line its interior, may now be seen to be provided internally with a spherical translucent utricle (which is the nucleus), an eye-spot situated peripherically and midway between the cilia and the opposite end of the cell, a contracting vesicle at the base of the cilia, and the pair of cilia themselves. Each pair of cilia passes out through a single channel in the gelatinous cell or envelope, which has now become much thickened—and thus their movements are limited up to this point,—while a defined line internally marks the boundary of the original cell-wall, through which, of course, the cilia also pass.

"During the second stage, each of the cells again undergoes duplicative division (the nuclei having been doubled previously); and the whole organism becoming larger, they are separated from each other, and being no longer subject to the compression which, with the lines of fissiparation tending towards the centre of the ellipse, and their confined position, induced a more or less conical and polygonal shape, now become spherical and enclosed respectively within distinct transparent capsules. The *Eudorina* is now 30-5400ths of an inch long, and contains thirty-two green cells, which are evidently situated between two large, ovoid, colourless, transparent cells, one of which bounds a similarly-shaped cavity in the centre of the *Eudorina*, and the other is the original cell-wall, round which again is the newly secreted envelope,—while the green cells are further fixed in their respective positions by the passage of their cilia through the two latter, both original cell-wall and envelope. Thus we see that the *Eudorina* is derived from a simple (daughter-) cell, and that its green cells have resulted from a duplicative subdivision of the green matter which lined the cavity of this cell. Arrived at this state, which we shall presently see is that of maturity, we also observe that the posterior part of the envelope becomes crenulated, apparently from flaccidity.

"After this, however, it again presents another phase, which may be called the third or last stage of development. Here *each cell* again undergoes a rapid duplicative subdivision into sixteen or thirty-two cells, which, in the group, assume a more or less oblong figure respectively; and thus the *Eudorina*'s length is increased to 50-5400ths of an inch. The internal structure now gradually breaks down before the external envelope, when for a short time the groups may be seen swimming about the cavity thus formed, till at last the envelope bursts and they become liberated. What becomes of them afterwards, I cannot state from observation; but the green cells having been greatly reduced in size by the latter subdivisions, it is probable that many of the groups, if they do not form new individuals, sooner or later become disintegrated, and the *Eudorina* thus eventually perishes.

"When, however, the process of impregnation takes place, the division stops at the second stage,—that is, when the *Eudorina* consists of thirty-two cells of the largest kind, each of which is about 1-1866th of an inch in diameter within its capsule, which is therefore a little larger. The process is as follows:—

"At a certain period after the second stage has become fully developed, the contents of the four anterior cells respectively present lines of duplicative subdivision which radiate from a point in the posterior part of the cell (and this distinguishes this subdivision from that which took place in the original cell from which the *Eudorina* was derived, and that which takes place in the third or last stage of development just described, where the lines of fissiparation tend towards the centre of the ellipse or ovoid cell). These lines, which ultimately divide the green contents of the cell into sixty-four portions, where the division stops, necessarily entail (from their radiating from a point and terminating a little beyond the centre of the cell) a pyriform shape on the segments, from whose extremities a mass of cilia may be observed waving in the anterior part of the cell of the parent, while yet her own pair of cilia are in active motion, and her eye-spot still exists *in situ* on one side of her progeny,—thus showing that the latter may be almost fully formed before the parent perishes. At length, however, this takes place, and the progeny, which we shall henceforth call 'spermatozoids,' separate from each other, and finding an exit, probably by rupture, through the effete parent-cell and her capsule, soon become dispersed throughout the space between the two large ovoid cells mentioned, where they thus freely come into contact with the capsules of the twenty-eight remaining or female cells.

"The form of the spermatozoid now varies at every instant, from the activity of its movements and the almost semifluid state of its plasma; and therefore, if we had not seen it in the parent-cell, it would be very difficult to define what this form really is. Its changes in shape, however, are confined to elongation and contraction, like those of *Euglena viridis*, and not polymorphic like those of *Amœba*; hence it is sometimes linear-fusiform or lunular, at others pyriform, short, or elongate. The centre of the body is tinged green by the presence of a little chlorophyll, while the extremities are colourless; the anterior one bears a pair of cilia, and there is an eye-spot a little in front of the middle of the body, also probably a nucleus. Thus we have a product widely different from the common cell of *Eudorina*. It is about 1-2700th of an inch long, and 1-10,800th of an inch broad.

"Once in the space mentioned, the spermatozoids soon find their way among the female cells, to the capsules of which they apply themselves most vigorously and pertinaciously, flattening, elongating, and changing themselves into various forms as they glide over their surfaces, until they find a point of ingress, when they appear to slip in, and, coming in contact with the female cell, to sink into her substance as by amalgamation. I say 'appear,' because, the female cells as well as the spermatozoids being so small, so numerous, and so nearly grouped together, and there being no point like a micropyle that I could discover, and the *Eudorina* continually undergoing more or less rotation, I do not feel so certain of having seen the act of union take place as if there had been only a female cell present with a fixed point for the entrance of the spermatozoids, as in the resting-spore of *Œdogonium*. But the act itself does not require to be seen; for the constancy of this form of *Eudorina*, the way in which these little bodies are produced, their plastic nature, and their behaviour towards the female cells are quite sufficient to convince those who have given their attention practically to such subjects that they are spermatozoids, and that there can be no other object in their congregating about the female cells than impregnation. If this be not sufficient, their number may frequently be seen to diminish as they pass backward among the female cells, when their disappearance can only be accounted for by their having become incorporated with the green cells. *Eudorina* in this stage also may frequently be seen with all the four anterior cells absent, and only a few spermatozoids left, most of which are motionless and adherent to the capsules,—indicating that the rest have disappeared in the way mentioned. Lastly, many *Eudorinæ* in this stage may be observed with not only the four anterior cells absent, but with hardly a single spermatozoid left,—indicating that the whole had passed into the female cells, or had become expended in the process of impregnation. I have never seen any spermatozoids in the central or axial cavity, nor do I think that there is a means of their escaping externally without rupture; so that their being confined to the space between the two ovoid cells of the *Eudorina*, where the green cells are situated, is another reason, if any more be needed, for considering them fecundating agents.

"What changes take place in the *Eudorina* after this, I have not been able to discover. At the time, the female cells appear to become more opake by the incorporation of the spermatozoids; and the crenulated state of the posterior part of the envelope in this stage seems also to indicate an approach to disintegration. I have also observed that those *Eudorinæ* which are undergoing, or apparently have undergone impregnation, are less active than the rest,—that is, those in which the spermatozoids are scattered throughout the interspace mentioned and applying themselves to the capsules of the green cells, and those in which there are only a few spermatozoids left. But even if they did become disintegrated, the latter, when free, would so closely resemble those of *Chlamydococcus*, which was also abundantly present, that unless the *Eudorina* could be found undergoing impregnation by itself, or apart from this organism, there appears to me no chance of distinguishing the two, and therefore no other means of completing this part of its history. It is true that the impregnated cells may undergo some change in form similar to those of *Volvox globator* after impregnation; but I think I should have seen this among the numbers which came under my observation, if it had been the case.

"While undergoing impregnation, the female cells always contain from two to four nuclei, as if preparatory to the third stage of development, into which they are sometimes actually seen passing, with the spermatozoids present and scattered among them; but the effect of impregnation generally seems to arrest this stage, and thus save the species from that minute division which leads to the destructive termination of *Eudorina* already noticed.

"Sometimes all the cells together undergo the spermatoid fissuration, when the *Eudorina* passes into *Pandorina Morum*, Ehr.; but in this case the development does not stop at the pyriform spermatozoids, but goes on to the development of thirty-two larger globular cells in each group, similar to those produced in the third stage of *Eudorina* above described, when they assume respectively a dome-shaped form, held together by a membrane which is fixed to the point in the posterior extremity of the cell from which the lines of fissiparation first radiated. As the groups, however, progress in development, this dome appears to become flatter, and, the *Eudorina* breaking up, as in the third stage, these groups, when liberated, finally appear to pass into the form of *Gonium*, when I think they perish like the corresponding groups of the third stage. I did not observe this development (in which may be included some abnormal states, where only one or two of the spermatic cells fail, and one or more of the female cells take on this mode of fissiparation irregularly) until the normal one of impregnation ceased to appear. Ehrenberg was wrong in giving the cells of *Pandorina* and *Eudorina* single cilia, as has before been stated, and partly wrong in leaving out the eye-spot, both of which, though disappearing ultimately, indicate the continued life of the parent-cell, as in the development of the spermatozoids, long after the formation of her progeny.

"Thus the process of impregnation in *Eudorina* agrees closely with that described by Dr. F. Cohn in *Volvox globator*, in which organism I had seen some of the cells of the interior undergoing a spermatoid development exactly like that above described, and also that previously figured by Mr. Busk, and alluded to by him as one of 'microgonidia;' and therefore the moment I perceived it in *Eudorina*, in connexion with Dr. Cohn's announcement, I felt convinced that the latter was right, and that I had before me *Eudorina* also undergoing a similar process of fecundation.

"So much for the spermatoid development; let us now return to that of the *Eudorina* in totality, concerning which there is still an interesting question for our consideration, bearing on the early development of this organism, which I have already stated my inability to supply, viz. how does the sixteen-division of the cell in the third stage of development take place, so as to allow the cilia to become external? It will be remembered that this cell in the second stage, before it passes into the sixteen-division of the third stage, consists of its capsule or cell-wall and the green contents; and it should also be remembered that, although these contents have now no other covering distinct from the protoplasm but the capsule, yet in all algal cells, whenever the green contents take on a new form, such as that of a spore or group of cells, a second more delicate covering is separated from them, for which I have heretofore used the term 'protoplasmic sac;' these two coverings, then, are the parental division of the mass, and become caducous as the rest takes on its new form and developes on *its* surface a cell-wall. Thus we get the sixteen cells separated from their capsule, &c., and surrounded by their proper cell-wall and the external envelope, which may be a still further thickening of the former, or a new secretion; but, be this as it may, the cilia are seen outside it. And at first it might be thought that they were formed before either the cell-wall or envelope, so as never to have been enclosed by either; but if this were the case, the cilia of the sixteen cells, which are added by duplicative division to the first stage of *Eudorina* to form the second stage, should be inside these coverings, or protrude through the original sixteen channels with the other sixteen pairs of cilia. However, neither is the case; for these sixteen cells have their channels respectively as well as the other sixteen cells, in which case they must have been made by the sixteen new cells themselves, unless the thirty-two-division is formed before the pellicle which subsequently forms the cell-wall is supplied, and our first stage does not pass into the second stage, but both forms are produced at once and separately from the beginning, —a point which can only be determined by following the development of the *Eudorina* from the spore itself, and that, too, alone, since it is impossible to say whether the sixteen-division groups, when previously mixed up with all the other forms of *Eudorina*, are or are not derived direct from the spore, or from the third stage of development of this organism. That the sixteen-division or second stage may pass direct into a similar form to the third—that is, into a form of *Eudorina* consisting of sixteen groups of sixteen cells each—I have occasionally seen; but then this form has been globular (only $\frac{30}{5400}$ths of an inch in diameter), and not ovoid, although the groups have possessed the latter form: perhaps this is the spore, and the sixteen groups the young *Eudorinæ*, if not a different species. Again, the robust individuals of the sixteen-division one would think to be direct from the spore, and to pass into the robust individuals of the second stage or thirty-two-division,—while the puny, meagre individuals one would think to come from the third stage, and,

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as before conjectured, end in disintegration and death. But all this, as I have just stated, can only be determined by following the development of the spore from the commencement. One fact I might add, however, viz. that the robust forms of good size have the power of withdrawing their cilia and protruding them again; this happens when they are transferred, from the vessel in which they may be contained, to the slide for examination: many may just at this time be seen to be motionless, with the channels for the cilia empty; but gradually the cilia are protruded through them, and as gradually the *Eudorina* evinces increasing power of motion, until they are fully protruded, and it swims away.

"*Chlamydococcus* undergoes the same kind of changes in development as *Eudorina*, from which it only differs in structure in being smaller, and globular instead of ovoid, in the absence of an external envelope, and in the cilia of the daughter-cells being *included* within the parent-cell; hence it also differs in being motionless, though the compartments of the daughter-cells are sufficiently large for them to turn round and move their cilia freely therein, which they are continually doing. The primary cell of *Chlamydococcus*, like that of *Eudorina*, divides up into 2, 4, 8, or 16 cells, and those of the eight- and sixteen-divisions again into groups of 16 or 32 each, so as to resemble the third stage of *Eudorina*. Hence we may perhaps infer that its fecundating process is similar to that of *Eudorina*; but this remains to be discovered. *Chlamydococcus* has also a great tendency to stop at the two- and four-division, from which it may pass into the 'still' or *Protococcus*-form, and, floating on the water in a kind of crust, present cells of all kinds of sizes undergoing 'still' division. In all its multiplications, partial and entire, however, it generally maintains its primary or spherical form, and does not become ovoid or oblong, like the groups of *Eudorina*, the only exceptions being in the two- and four-division, where the green cells are sometimes ovate (probably from want of room in the parent capsule), as represented by Ehrenberg in *C. Pulvisculus*,—to which I should refer it, had he not also given an ovate form to the type-cell of this species; nor can I refer it to *C. pluvialis*, for in all the changes I have yet seen it undergo, the red colour has not increased beyond the minute eye-spot, while this also disappears, and the cilia too, when this species passes into the 'still' form. Here it undergoes the same kind of division that it does in the active state; but the parent-cell, instead of becoming distended by imbibition, remains closely attached to the daughter-cells, so as to give the group a mulberry shape. How long it remains in the 'still' form I am ignorant; but having only seen it in the active state during the months of May, June, and August, and throughout the rest of the year in the 'still' one, I am inclined to think that it only comes into the active state during the summer months, and then for the purpose of fecundation.

"In several instances, also, where I have found this *Chlamydococcus* with *Eudorina*, they have been accompanied by long Closteriform cells. It was the case in that above mentioned, where the latter was undergoing impregnation. Some of these have an eye-spot, which, with the nature, arrangement, and general aspect of their internal contents, show that they belong to the class of organisms with which they are associated. Their cell-wall also is more or less plastic, or was so when they were assuming this spicular form; for many have one or more *diverticula* extending from them, some are bifid, and a few irregularly stellate. What they are I know not; but Dr. Cohn has figured the same kind of cells, in company with *Sphæroplea annulina*, under impregnation."

Stephanosphæra.—To Dr. Ferdinand Cohn, to whom science is so deeply indebted for his researches among the simplest organisms of creation, additional thanks are due for the elaborate essay on a new genus of *Volvocineæ*, in which he has most philosophically displayed the structure and relations of that family at large. The new genus is named by him *Stephanosphæra*, the structural and physiological characters of which have been presented to the English reader by an excellent translation of Cohn's original paper, in the *A. N. H.* 1852, x. p. 321 *et seq.* Besides this account of *Stephanosphæra* by its discoverer, none other exists; we must accordingly make extensive use of it in attempting an abridged description,—a difficult task on account of the importance of almost every paragraph it contains.

The organisms to be described "exhibit an extraordinary variety of size and shape," writes Cohn; "but they are all essentially of similar structure, and consist of eight *green spherical corpuscles having their central points situated at the circumference of a circle* (XIX. 38), *and of a large common envelope, enclosing the former as a colourless vesicle, at the equator of which are ranged the said eight green globules* (XIX. 40–58).

"The common envelope is bounded by a membrane wholly devoid of structure and transparent, so that it may be overlooked if the illumination be not properly modified, under which circumstances the 8 green globules appear destitute of any common bond of union. But the *membrane* of the envelope always exists; and although very delicate and thin while young (XIX. 57–58), it becomes thickened with age, and then possesses an evident breadth, albeit no compound structure can be detected. *The membrane of the envelope is absolutely rigid*, and never changes its shape, excepting through the ordinary expansion of growth; therefore it is not only totally devoid of contractility, but is even elastic only in a slight degree.

"In whatever direction the total organism may lie during its movements, the envelope always appears as a perfect, absolutely regular circle (XIX. 38, 39); thence it results most decidedly that the *membrane of the envelope forms a sphere* which may perhaps deviate but very little from the mathematical ideal. The diameter of the envelope varies between tolerably wide limits: while some younger forms possess an envelope $\frac{1}{80}$th of a line (0·028 mm.) in diameter, most attain one of $\frac{1}{50}$th (0·044 mm.), and the largest are as much as $\frac{1}{40}$th of a line (0·055 mm.) in diameter.

"The phænomena in dissolution and during propagation prove that the membrane of the envelope immediately surrounds a colourless watery fluid, the refractive power of which does not differ from that of water. The envelope may therefore be regarded as a broad spherical *cell* with a delicate structureless membrane, colourless and transparent like glass, *containing* a thin, water-like, colourless fluid; consequently I shall denominate it the *envelope-cell* (*Hüll-zelle*).

"While the envelope-cell varies, generally speaking, only in size, and no difference whatever of shape and structure can be detected in the different individuals, the variations in the development of the eight *green globes* in its interior are very great. In fact it is difficult to represent the multiplicity of forms which here display themselves, so as to give a full and clear idea of them; and our figures even can afford but a very insufficient picture, since scarcely a single individual exactly resembles another in this respect. The eight green bodies in the interior of each envelope-cell, which, for reasons to be given hereafter, I shall call *primordial cells*, are in their simplest condition globular, and stand at equal distances in a circle at the largest circumference of the envelope-cell, so that the whole structure looks like a hollow glass globe with a ring formed of eight green globules in its interior (XIX. 38). If the circular line in which the centres of the eight primordial cells stand, is regarded as the *equator of the envelope-cell*, we ordinarily find their position such that the equatorial zone lies parallel with the plane of the object-glass, and the observer consequently looks down upon the pole of the envelope-cell. In this, the *polar view*, the eight primordial cells stand in a perfect circle and are placed very close to the circumference of the envelope-cell. The distances between the primordial cells are more or less considerable according as they are proportionately larger or smaller; sometimes they constitute an elegant wreath composed of eight large green rosettes, almost without any intervals between them, or resemble an interrupted eight-angled star; sometimes the green globules are so far apart as to look like the eight spokes of a wheel. The diameter of a primordial cell in the polar view amounts in the former case to $\frac{1}{180}$th of a line (0·012 mm.), in the latter to $\frac{1}{350}$th (0·0065),—on an average to $\frac{1}{250}$th of a line (0·0087 mm.).

"When, however, the whole revolves, so that the axis passing through the two poles of the envelope-cell lies parallel with the stage of the microscope, and the equatorial zone marked by the eight green primordial cells stands perpendicular to the latter, consequently in the optic axis of the microscope, the envelope-cell still looks like a circle, because it is a sphere; but the eight primordial cells, lying in one plane, are then projected in a line which corresponds to the diameter of this circle, so that the whole resembles, under the microscope, a colourless disk cut in half by a green zone (XIX. 40–58). And in this, the *equatorial view*, according to the position, the four primordial cells in the anterior hemisphere sometimes completely cover the four behind, so that only four are seen altogether; sometimes the latter appear through the interspaces between the former, and all eight are seen in one line. This view also, of course, gives very different pictures according to the size of the primordial cells and the distance between them.

"Between the polar and equatorial views lie countless intermediate positions in which the ring of primordial cells, more or less contracted, appears as an ellipse, with its longest axis constantly in the diameter of the envelope-cell, while the shorter axis appears longer or shorter, and the separate primordial cells are approached more or less towards each other, according to the laws of projection.

"Besides this difference of the aspect which one and the same individual affords merely in consequence of the different *positions* resulting from its movements, a still greater variation is displayed in the *shape of the green primordial cells themselves*. I have called them globes above; properly they are always acuminated to some extent, in the form of a pear, toward the periphery of the envelope-cell; and they are imperceptibly attenuated to a point here, from which *two cilia* pass out (XIX. 38). *These cilia therefore arise from the primordial cells inside the envelope-cell*, and they emerge freely into the water through minute orifices in the latter: from the analogy with *Chlamydococcus*, I conjecture that there is a separate passage for each cilium, so that the orifices corresponding in each case to the primordial cells are placed in pairs, and all sixteen orifices occur in the equator of the *envelope-cell*. Hence in the polar view the eight pairs of cilia go out from the circumference of the envelope-cell like elongated rays.

"The primordial cells moreover *expand principally in the direction of the axis perpendicular to the equatorial plane*, so that in the equatorial view they appear not spherical, but rather elliptical, or even sometimes stretched so considerably in this direction, that they become cylindrical or almost spindle-shaped, without undergoing any remarkable enlargement on the other axis. If in this case the primordial cells are large and near together, they form in the equatorial view a broad green zone inside the colourless envelope-cell, filling up a more or less considerable portion of this (XIX. 39), while in the polar view they form only a circular wreath. In some instances the proper green body of the primordial cells is only shortly cylindrical; but it becomes elongated at both ends into long beaks which reach almost to the poles, and give each primordial cell something of the shape of the *Closterium setaceum* figured by Ehrenberg. In this case the whole resembles a sphere surrounded by eight green bands placed in meridians and swollen only in the equatorial region. But even in this very frequently occurring preponderating development of the one dimension, the cilia of each primordial cell are sent out from the middle of its shorter axis; and when the primordial cells appear projected in a zone, in the equatorial view, the motile cilia are visible only at four points of the diameter.

"The primordial cells are very frequently developed unequally in the two hemispheres of the envelope-cell; they are not then divided into two equal halves by the equator of the envelope-cell, but show themselves crowded principally into one hemisphere, which they almost fill; and they reach almost to the pole there, while they occupy but a far smaller portion of the other, which consequently appears in greater part colourless. In such a case the primordial cells almost touch with one end, while they diverge widely at the other, and thus they look like a kind of basket composed of eight pieces, like the gaping dental apparatus of a Chilodon.

"Besides the two cilia which pass out from each primordial cell, through the orifices of the envelope-cell into the water, the former very frequently send out other prolongations, which however do not perforate the envelope-cell. These are *colourless mucilaginous filaments, going out from each primordial cell, especially from the ends of their longer axis*, and which hence present themselves especially clearly in the equatorial view. The ends of the primordial cells are mostly not green but colourless, and elongated into numerous, likewise colourless, broader or thinner bristle-like processes, which run out like rays in all directions, are often ramified, and are attached to the inside of the envelope-cell, without however perforating it (XIX. 39). If these filaments are much developed, they form a proper network, which maintains each primordial cell floating in the common envelope. The extremities of the primordial cells are also frequently divided dichotomously into colourless mucilaginous bands, which again branch into radiating filaments and thus produce the most wonderful forms. These colourless filiform prolongations of the primordial cells may also be seen in the polar view, stretching in all directions, and giving the total structure a most strange aspect, almost similar to that of a Xanthidium.

"In the *internal organization of the primordial cells*, all that can be made out is a green-coloured softish substance, of which they are composed, and in which numerous delicate granules or points are imbedded. When the primordial cells are actively vegetating, they are of a transparent vivid green; but the colour exhibits various tints: in the youngest conditions it is purer, more yellowish green, less obscured by dark points; in the largest forms, on the contrary, the contents appear brownish green and opake, with the dark granules multiplied to such an extent, that the whole almost loses its transparency. In the middle of the primordial cells are found *two larger, nucleus-like vesicles*, mostly symmetrically placed; and these examined separately appear annular, *so that they possess an internal cavity*; iodine colours them remarkably dark, with a violet tinge (XIX. 39). The centre of each primordial cell is frequently occupied by a lighter circular space, which however does not vanish periodically, and therefore cannot be regarded as a contractile vesicle (XIX. 38).

"*The primordial cells are not surrounded by any special rigid membrane*;

and this is not only made evident by the multifold changes of form which they undergo in the course of vegetation, and by the filiform prolongations and ramifications which are produced directly from their substance, but is clearly shown by the transformations which the primordial cells pass through in consequence of external influences. Under certain circumstances, namely, the filiform processes may be retracted, being torn away from the envelope-cell and taken up into the substance of the primordial cells; the produced ends of the primordial cells also disappear, the latter becoming rounded off into their original spherical or short-cylindrical form. Such a change would be impossible if the primordial cells were surrounded by a rigid membrane, such as that of the *envelope-cell* for example. Still more rapid and decided are the metamorphoses which the primordial cells undergo in the interior of the envelope-cell, through influences destructive to the life of the organism. These phænomena, usually called *dissolution*, do not change the rigid envelope-cell at all; but they totally decompose the primordial cells, depriving them of their form and dissolving them into a single structureless green mass, which lies upon the inside of the envelope-cell, frequently destroying all evidence of the origin from eight spheres, while not a trace of special enveloping membranes comes to light. These phænomena of dissolution moreover indicate that the envelope-cell, as I have already mentioned, is composed *of a delicate membrane enclosing a clear watery fluid*, which cannot be dense, gelatinous, or mucilaginous, since it is readily displaced by the radiating filaments and the dissolved substance, and which therefore is very similar to pure water, if not exactly the same.

"*Motion.*—The *cilia* which are protruded from the equator of the envelope-cell are but short inside this; but the portion projecting into the water is much longer and vibrates actively, thereby causing all the movements. During their vibration the cilia are difficult to detect; but when dried on glass, and still better by wetting them with iodine, they may readily be traced in their whole length, especially if sulphuric acid is added, this rendering them more distinct and giving them a darker colour. The motion of the entire organism, depending on the eight pairs of cilia, exactly resembles that well known in the Algæ and many Infusoria. First there is a rapid revolution round that axis of the envelope-cell which passes through its poles and stands perpendicular to the ring of primordial cells, so that the envelope-cell rotates like a wheel upon its axle. In the polar view (XIX. 38), our form gives exactly the impression of a revolving wheel, while in the equatorial view (XIX. 39), where the primordial cells are mostly elongated, it has more the aspect of a globe turning upon its axis. Besides this revolution on its axis, which endures throughout the whole life, there is an advancing movement, which produces a very irregular course; in this way these organisms *screw* themselves, as it were, onwards in the water. Sometimes they swim straight out with uniform rapidity, the pole going first, the rotating ring of primordial cells standing at right angles to the course and appearing only in one line; sometimes they turn round, so that the equatorial plane presents itself as a circle again (in the polar view): they rotate thus round their centre without moving from the spot; then they set one pole forward and swim on in another direction, bend to the right or to the left, or turn quite round, mostly without any perceptible obstruction, move in curves of the most varied kinds, run round any point in spiral lines, come into different planes, sometimes ascending, sometimes descending; in short, they exhibit all those most complex and wonderful dhænomena of locomotion which we are acquainted with in the moving propagative cells of the Algæ,—and, as I have demonstrated elsewhere, in *exactly the same way* in the *Astomous* and *Anenterous Infusoria* (*Monadina*, *Astasiæa*, *Cryptomonadina*, &c.), and which certainly do not bear at all the character of purposing, conscious volition, but appear as an activity determined not indeed by purely external causes, but by *internal* causes in the organization and vital process. The collective idea of such motions is best represented by the course described by a top which runs through the most varied curves while at the same time constantly revolving on its axis.

"Although Alex. Braun describes a *constant* revolution to the left in the in many respects analogous swarming-cells of *Chlamydococcus* and the swarming-spores of *Œdogonium*, and to the right in the moving gonidia of *Vaucheria* and the families of *Pandorina*, I must assert *that no such constant law of revolution exists in the structure here described.*

"*As to its systematic position.*—It is evident *that the organism we have described belongs to the family of the Volvocineæ.* For not only do we find in it the two principal characters which are characteristic of this interesting family—the presence of a number of green globes which, enclosed in a common colourless envelope, represent a family of cells (polypidom), together with the constant rolling motion which the *Volvocineæ* possess through almost the whole of their life,—but our form also displays, as we shall see hereafter, the third character of the *Volvocineæ*, that the separate globes propagate within the envelope. In fact, there exist the greatest analogies between the known genera of *Volvocineæ*, especially *Gonium* and *Pandorina*, and the organism here described; and these genera are only essentially distinguished by the arrangement of the green globes or primordial cells, which in *Pandorina* are placed on a spherical surface, in *Gonium* on a flat plane, while in our form they stand at the circumference of a circle. Since, however, this very law of arrangement is, in the family of the *Volvocineæ*, the most important criterion on which the establishment of the genera depends, it follows that we here have a peculiar genus which I do not find described either in Ehrenberg's great work or in any later publication.

"If we now compare the conditions of organization of *Stephanosphæra* with those of *Chlamydococcus*, we find the most essential agreement. In the first place the envelope-cell of *Stephanosphæra* corresponds exactly to that of the moving macrogonidia of *Chlamydococcus*; it is composed of a delicate colourless membrane and contents resembling water. Chemical actions to which I subjected the envelope-cell of *Stephanosphæra*, bear witness of this agreement in the most minute particulars. The envelope-cell is indifferent to acids and alkalies and is not dissolved in them; but it suffers a peculiar thickening by sulphuric acid, which causes it to apply itself more closely to the primordial cell, and present itself very distinctly and clearly defined. In general the application of *dilute sulphuric acid* is often the best means of making clear delicate vegetable membranes which would otherwise be readily overlooked, especially when iodine is added, which then ordinarily colours the membrane yellow. The cilia also are rendered more distinct by sulphuric acid. The envelope-cells of *Pandorina, Chlamydococcus*, and *Volvox* behave in exactly the same way.

"With regard to the chemical composition of the envelope-cell of *Stephanosphæra*, I have *succeeded in demonstrating the characteristic reaction of vegetable cellulose, the blue colouring by iodine and sulphuric acid, in the envelope-cell of Stephanosphæra.* For this purpose it is requisite to allow a drop of *pretty concentrated sulphuric acid* to act upon the swarming *Stephanosphæra*-globes until the green primordial cells in the interior are decomposed,—by which time the proper transformation of the envelope-membrane has taken place, and a drop of solution of iodine (iodine in iodide of potassium), sufficiently diluted to prevent the sulphuric acid precipitating it in crystals, then produces a coloration of the envelope, which appears *at first violet, gradually becoming more intense, and at last beautiful indigo-blue.* Thus the chemical behaviour of the envelope-cell in *Stephanosphæra*, as in *Chlamydococcus*, is the most evident proof that the organisms to which they belong cannot be regarded as Infusoria, but are simply Algæ. Moreover this behaviour of the envelope-cell of *Stephanosphæra* shows that the latter is bounded by a true cellulose membrane, and not, as is assumed almost universally of the *Volvocineæ*, and by Nägeli even of all Algæ, of secreted mucus or jelly. The direct observation of the envelope-cell of *Stephanosphæra* likewise shows that this is completely closed in its normal condition, and only perforated by orifices in the spots where the cilia of each primordial cell pass out. Not until a later stage, when the primordial cells singly leave the envelope or have begun to propagate, does the membrane of the envelope tear, gradually collapse, and become dissolved, so that the included globes can make their exit freely.

"It is obvious that the eight green globes of *Stephanosphæra* correspond exactly to the primordial cell of *Chlamydococcus*. The primordial cells of *Stephanosphæra* consist in like manner of nitrogenous protoplasm, in itself colourless, which is coloured brown by iodine and almost wholly dissolved by caustic potash and ammonia. The protoplasm is coloured by the universal colouring matter of vegetables, *chlorophyll*; for alcohol and æther bleach the green globules, and concentrated sulphuric acid changes the green colour into a verdigris-green or blue,—a reaction which, from my observations, is characteristic of chlorophyll.

"The chemical nature of the fine granules in the primordial cells, which with age multiply so that the primordial cells at length lose their transparent green colour and appear dull, opake, and olive-brown, is difficult to determine on account of their small size; they are either *protoplasm-granules*, or, as a bluish colour given by iodine might leave one to conclude, perhaps *starch-granules*. On the other hand, the *two darker nuclei* in each primordial cell are undoubtedly the same structures which occur in *Chlamydococcus* and, in like manner, not only in all the *Volvocineæ*, but also in most of the Algæ of the orders of *Palmelleæ*, *Desmideæ*, *Conferveæ*, &c. Nägeli has called these *chlorophyll-utricles*, and demonstrated their universal occurrence in the vegetable kingdom by comparative descriptions (*Gattung. einzell. Alg.* ii.). Ordinarily there exist only *two* in *Stephanosphæra*, which may be distinguished in the earliest stages,—while, among other *Volvocineæ*, for instance, *Gonium* contains only *one chlorophyll-utricle*. It is difficult to settle anything definite concerning their structure and function; they must not be regarded as cell-nuclei, although they resemble them very much, especially when only one is present. Caustic potash, which destroys the rest of the contents of the primordial-cells, makes the chlorophyll utricles of *Stephanosphæra* show themselves more distinctly as hollow rings, surrounded by a membrane which is rather granular; iodine colours them *deep violet*, which leads to the conclusion of the presence of starch. Ehrenberg thought the chlorophyll-utricles were to be recognized as the testes of the *Volvocineæ*; it is certain, however, that these structures may be seen in greater or less number, in exactly the same way, in undeniable plants, such as *Hydrodictyon*, *Œdogonium*, *Mougeotia*, and others.

"I have already shown that the primordial cells of *Stephanosphæra* as well as those of *Chlamydococcus* are destitute of a special rigid membrane; consequently they do not correspond to perfect cells, but on the whole only to primordial utricles. In like manner the curious colourless mucous filaments which extend out from the extremities of the primordial cells of *Stephanosphæra* are evidently analogous to the rays which make one condition of the *Chlamydococcus*-cells look hairy (var. *setiger*, V. Flotow). They are merely prolongations of the colourless protoplasm forming the substance of the primordial cells, and correspond pretty well morphologically to the reticulated branching filaments of protoplasm, the sap-currents as they are termed, which maintain the nucleus suspended freely in the interior of the cells of the articulations of *Spirogyra* or of the hairs of the anthers of *Tradescantia*. Alcohol and acids cause these prolongations to be retracted into the substance of the primordial cells; the same thing takes place during the course of the development. Ehrenberg has called these peculiar mucous rays, which also occur in some other *Volvocineæ*, in some cases a *tail* (*Synura*, *Uroglena*), in others connecting canals or indications of a vascular system (in *Volvox* and *Gonium*). These protoplasm-filaments naturally present a different aspect according to the shape and arrangement of the primordial cells: while they appear as a wreath of cilia in the globular *Chlamydococcus*-cell, in the more spindle-shaped *Stephanosphæra* they rather resemble bundles of rays passing out from each end; in *Volvox*, if seen only from above, they give the individual primordial cells a polygonal, radiating aspect, and form threads of communication between them: Focke has wrongly considered them as intercellular passages between the individual animalcules. The connecting threads in *Gonium*, on the other hand, are something quite different, and do not belong at all to the domain of the protoplasm-filaments, as I shall explain more fully at another opportunity.

"Thus the microscopic analysis, like the chemical investigation, of *Stephanosphæra*, in exact analogy with *Chlamydococcus* and the swarming-cells of the other Algæ, has enabled us to distinguish all the characters of a plant, but not one mark of a true animal organization, in particular not a trace of a mouth, stomach, and sexual organs. But the genus *Stephanosphæra* is thereby pre-eminently important for the decision of the question of the limit between the animal and vegetable kingdom, *because the history of its development affords the most convincing proof of the vegetable nature of this genus, and thus of all the other* Volvocineæ.

"*Development of Stephanosphæra.*—Both the very delicate envelope-cell and the widely distant, transparent, green, globular, primordial cells of the young *Stephanosphæra* are of a relatively small size. Both grow so much as to double their dimensions during their vegetation: the former acquires a tough membrane; the latter fill up the greater part of the envelope-cell, advance towards each other so as to touch, develope thicker, denser contents, and assume most curious forms through the ramification of the protoplasm-filaments. Finally the process of propagation shows itself in the primordial cells. The radiating ends retract all their prolongations, and become rounded into a perfect sphere; the primordial cells are now merely attached to the envelope-cell by their cilia, and thus are readily moved from their normal corresponding positions, and then appear devoid of any definite arrangement in the envelope-cell.

"These changes take place in the course of the afternoon; towards evening more influential metamorphoses make their appearance. The primordial cell, namely, extends itself predominantly in *one* direction in the axis perpendicular to the equatorial plane, consequently in the position which represents from above downwards. The two chlorophyll-utricles respectively repair to the two ends; the green contents likewise flow chiefly to the two sides, and leave a broad colourless zone visible in the middle, such as we observe somewhat in the same position in *Closterium*. Finally the primordial cell becomes constricted, gradually from the periphery to the centre, in the middle line, and is thus divided into two secondary cells, the septum of which, in the position above assumed, runs from right to left. Each of the halves cut off by the division then expands somewhat in the direction from left to right; a new constriction soon presents itself in the direction from above downwards; when this is complete, the originally globular primordial cell is divided into four quarters (XIX. 40).

"This process of constriction and cutting off is repeated *once more*, each secondary cell becoming divided by a new septum into two equal halves (XIX. 41–56).

"This process of division, by which each primordial cell produces in the first generation two, in the second four, and in the third eight secondary cells, is completed in the course of the night, so that early in the morning, in the long summer days even by 3 o'clock, we perceive each of the eight primordial cells divided into eight in the manner described (XIX. 41, 42). The generations produced in each case by this triple subdivision vary in the duration of their lives and in their capacity of development; the first two rapidly divide again, and therefore are, according to Nägeli's expression, mere '*transitional generations*;' the third alone arrive at complete development and persist a long time as such; these form the '*permanent generation*.'

"The process of division does not always take place simultaneously in all the eight primordial cells of *Stephanosphæra*; we not unfrequently find inside the same envelope-cell some primordial cells still wholly unaltered, while others are already preparing to divide into two, a third perhaps already into four, and a fourth has already resolved itself into its eight secondary cells. Very often most of the primordial cells are found already completely separated into eight, while one or other of them is still wholly unaltered.

"When the act of division has gone on favourably up to the point to which we have followed it above, some hours elapse before the young families of cells escape completely from the envelope. The process which precedes their birth consists principally in the more complete isolation, in a centrifugal direction around their common centre, of the secondary cells produced by *each* primordial cell. Since the parting off of the secondary cells advances gradually from the periphery towards the centre, they are already completely individualized and separated by intercellular spaces at the periphery, while all eight remain still connected in the centre into a common colourless mucous mass filled with protoplasm-granules (XIX. 42). But the flow of the contents from the centre to the borders, which continues up to this time, at length causes the constriction of the central mass of protoplasm also into eight parts; the eight secondary cells then appear of a deep yellowish green externally, passing internally into colourless green towards finely granular beaks which are all connected in the centre, but become gradually attenuated, torn away, and retracted. Then the young primordial cells become rounded into short cylinders and stand in a circle, without organic connexion, but placed closely beside one another: seen from above (in the polar view), under the microscope, they resemble a wheel with eight notches; from the side, examined in the equatorial view, we see four or eight short cylinders lying side by side,—so that the whole is not unlike a small *Scenedesmus obtusus* (XIX. 57–58).

"The primordial cell undergoing division behaves as a *whole* towards external things, until the parting off into eight is quite completed; that is to say, its two cilia move uninterruptedly, and consequently the entire *Stephanosphæra*-globe still rolls through the water according to the known laws, even when most of its primordial cells have already become more or less completely divided into four or eight secondary cells. Only shortly before the completion of the division do the cilia of the *parent-cell* lose their motion and disappear, it may be by being retracted or by being thrown off; but the orifices through which the cilia previously passed out into the water may now be observed in the common envelope-cell, as minute points surrounded by a thickened border.

"Immediately after that, it is seen that the newly-formed secondary cells have developed their own cilia; for the young generations formed in the interior of the parent-envelope now begin to move and to roll over like a wheel, so far as the confined space allows of this. In consequence of this movement of the eight small wheels rotating in the interior of the common envelope-cell, which constitutes a very pretty object, the parent-cell soon becomes enlarged and attenuated at certain points; the cellulose of which it is composed appears to be transformed into soluble jelly, and soon afterwards one after the other breaks through out of the common envelope and revolves freely and independently in the water, according to the same laws as the old spheres, but more actively and energetically. The young *Stephanosphæra* exactly resembles a green wreath composed of eight small cylinders, upon which by itself no envelope and cilia can be detected (XIX. 42, 48, 49); but if killed with iodine, the eight primordial cells are seen to be surrounded by a common envelope-cell in the form of an exceedingly delicate membrane,—only this lies in all parts almost immediately upon the green globes, so that it follows the waved outline they produce, and in its total form resembles a flat spheroid with eight notches on its border; it is perforated by the cilia, which go off in pairs from each of the primordial cells; and two chlorophyll-utricles are already distinguishable in the latter. By degrees the envelope-cell is lifted up by the endosmotic absorption of water; its surface becomes smoothed out, and it appears circular in the polar view; *on the other hand, it retains for a longer time the form of an almost tabular spheroid, and hence presents an ellipse in the equatorial view* (XIX. 58); finally it expands uniformly in all directions and thus acquires its normal spherical form, while at the same time it becomes considerably thickened. This whole process of propagation is completed during the night; and on bright days *Stephanosphæræ* are rarely seen in course of division at sunrise; on dull days they may be observed in this condition in the first part of the morning.

"The primordial cells, however, not unfrequently come to a standstill in the stage of division of the second generation, so that they only separate into four secondary cells; these at once develope cilia and an envelope-cell, without dividing a third time, and make their exit from the parent-envelope in this condition. Here therefore only the *first* generation of each primordial cell is a *transitional generation*, the *second* already a *permanent generation*. Hence arises the circumstance that we often find, among other eightfold *Stephanosphæra*-globes, some in which the envelope-cell encloses only four primordial cells standing at equal distances, which in other respects behave in the ordinary manner.

"It is still more frequently observed, when the primordial cells have already become constricted into four secondary cells and are beginning to divide again into eight, that this process of division is not perfectly completed in all four portions, but that the young *Stephanosphæra* already becomes free and developes the envelope-cell, *although one or other of the four quadratic segments of the sphere has become constricted but not parted off*. Hence originate monstrous forms, since the general envelope-cell then encloses only seven primordial cells; but in these cases it is always observed that one of them is distinguished by most curious prolongations or mucous filaments, that it appears twice as large as the rest, that it contains four chlorophyll-utricles instead of two as is usual, and that it is also more or less constricted in the middle. All this furnishes proof that here *one* secondary cell of the second generation has not been divided the third time like the rest, but occupies by itself the space which is ordinarily filled by two. Very often only six, or even no more than five primordial cells are found in one envelope-cell; but then two or three of these are twice as large as elsewhere. In like manner Alex. Braun figures a *Pediastrum* composed of fifteen instead of sixteen cells, wherein one, however, is twice as large as the rest.

"On the whole, it is obvious that the mode of propagation of *Stephanosphæra* already examined corresponds completely to that we are already acquainted with as *formation of macrogonidia* in *Chlamydococcus*. It both cases it depends upon the envelope-cell remaining unaltered, while the primordial cells become divided, first into two secondary cells, and then so on in a lower power of two, each of the secondary cells immediately developing two cilia, and secreting over its whole surface, as do all primordial utricles of vegetable cells, a delicate cellulose membrane, which, however, becomes gradually removed further from the secreting primordial cell through absorption of water. The only distinction between *Chlamydococcus* and *Stephanosphæra* arises from the formation of a special envelope-cell to each individual secondary cell in *Chlamydococcus*, while in *Stephanosphæra* all the generations produced by division form *one* primordial cell, become enclosed by a common envelope, and move away as *families of cells*. On the contrary, the developmental history of *Gonium*, *Pandorina*, and *Volvox* agrees in all essential particulars with the laws of propagation which I have just described in *Stephanosphæra*, as will be shown elsewhere. We may call the mode of multiplication of the *Volvocineæ* by the general name of *propagation by macrogonidia*.

"Another process is met with in *Stephanosphæra*, besides the above, and which I have observed more rarely, viz. *propagation by microgonidia*. In this mode of multiplication the introductory processes are exactly like those of the formation of macrogonidia; in particular each primordial cell is at first divided into two, then into four, and lastly into eight secondary cells. But instead of this third generation being permanent and becoming free, as is usual, it not unfrequently happens that the process of division is not arrested with the separation into eight—that the original primordial cell becomes parted off a fourth, fifth, and even a sixth time, in the same manner, and *at length is broken up into a large number of cells* (16, 32, 64), which naturally are so much the smaller the greater number of times the subdivision into two has taken place (XIX. 43, 51). These *little secondary cells finally become totally separated from one another*, without secreting an envelope-cell. These little cellules—I shall follow the example of Alex. Braun and call them *microgonidia*—exhibit a very active and energetic motion inside the envelope-cell, hurrying very rapidly up and down in all directions in its cavity, producing by their great number that curious swarming which Alex. Braun has very aptly compared with the intermingling of a crowd of people in a confined area, where every one is constantly changing his place, while the whole together constantly occupy the same space. Sometimes the cellules are scattered in a few large masses; then they unite again into a knot in the middle; every moment the general aspect varies. At length the common envelope is ruptured where the microgonidia emerge one after another or in large masses, but free and singly, into the water. Their true form may be then readily detected by killing them with iodine; they are *spindle-shaped* and acuminated at both ends, bright green in the middle, and run out into a colourless beak at each end, on the whole not unlike young *Euglenæ*, without a trace of an envelope-cell; the extremity which goes first in their swimming bears delicate cilia; the *number of the cilia is four* (XIX. 52). When the microgonidia reach the water they move most actively in all directions, and in a short time all the corpuscles emitted from an envelope-cell are scattered and disappear in the wide surface of the drop of water.

"I have not been able to make out what becomes of the microgonidia subsequently, since they are ordinarily decomposed on the object-holder after a brief swarming; but it may be conjectured that they also serve for propagation, and probably pass into a condition of rest. At least the latter has been observed in the microgonidia of *Chlamydococcus pluvialis* by Alex. Braun and myself: the history of the development of the latter agrees wholly with those of the *Stephanosphæra*; they originate also by the division of the primordial cell in a higher power, are distinguished by their minute size and more active, peculiarly Infusorioid movement, and never develope an envelope-cell during their movement. The microgonidia of both therefore are true primordial cells; that is, primordial utricles resembling cells, organized exclusively of coloured protoplasm, without any cellular membrane. The only distinction between them is, that the microgonidia of *Chlamydococcus*, like their macrogonidia, possess *two* cilia, while in those of *Stephanosphæra* I observed *four*. That the microgonidia of *Stephanosphæra* correspond perfectly in morphological respects to the macrogonidia, and only depend upon a higher power of division, is proved by a case in which seven out of the eight primordial cells in one envelope-cell were broken up into microgonidia, while *one* divided merely into *eight* secondary cells; the latter were developed as macrogonidia, and formed a connected wreath surrounded by an envelope-cell, which rolled slowly about in the parent-envelope, surrounded by the swarm of free, rapidly moving microgonidia.

"Abstracting the differences which may be shown always between two genera, we detect the *same law of development* in *Hydrodictyon* as in *Stephanosphæra*,—viz. the biciliated less numerous macrogonidia arrange themselves into a *family of cells* already within the parent-cell, according to the character of the given conditions of the two genera, the cell-family being active in the *Volvocineæ* and immoveable in the *Protococcaceæ*, while the more numerous more actively moving microgonidia with four cilia leave the parent-cell and enter upon a metamorphosis, the retrogradation from which to the normal type of the genus has not been observed yet here, or indeed in the microgonidia of any of the Algæ. Such an undeniable agreement of the law of development of *Stephanosphæra* with an undoubted plant like *Hydrodictyon*, which testifies to a near relationship, would be inconceivable if the former were to be regarded as of essentially different organization—as belonging to quite another kingdom of nature. Thus the developmental history of *Stephanosphæra* also furnishes the most convincing proof of the vegetable nature of this genus, and consequently of the *Volvocineæ* generally.

"That the formation of macro- and microgonidia does not exhaust the whole series of forms which *Stephanosphæra* may pass through, is proved by the following observation, which unfortunately I have not yet been able to complete. Having cultivated some *Stephanosphæra* for a long time in a little glass cup, in the way described in my essay on *Loxodes bursaria* (*l. c.*), all the primordial cells at length exhibited dark, thick, greenish brown contents, so densely filled with numerous granules that the two chlorophyll-vesicles could no longer be detected; their form was more or less globular, and the mucous radiating processes were entirely absent; their outlines were remarkably sharply defined, as if they had become surrounded by a rigid membrane. At the same time I remarked that the primordial cells were no longer fixed immoveably at the periphery of the envelope cell, never changing their relative positions, but *jerked backwards and forwards, finally tore themselves away from the envelope-cell, and then began to rotate slowly and lazily in the interior.*

Soon after, I saw the envelope-cell also burst at some spot and collapse; and the eight primordial cells gradually emerged, one after another, as independent globes: they were now seen to be *enclosed in a pretty closely applied envelope*, through which penetrated two cilia; and hence they presented the utmost resemblance to *Chlamydomonas Pulvisculus*. They moved about for some time in the water and *at length came to rest, losing their cilia and accumulating like little green Protococcus-globules at the bottom of the glass.* We therefore have here a motionless, perfectly plant-like stage of *Stephanosphæra*, such as we are acquainted with in *Chlamydococcus* and *Chlamydomonas*; the remainder of the *Volvocineæ* undoubtedly pass into a similar condition of rest, which is the means of their preservation when the water of ditches is dried up in summer. The emergence of single globes from the common envelope, in a form resembling *Chlamydomonas*, may also be readily observed in *Gonium*.

"I conjecture that the motionless Protococcoid cells of *Stephanosphæra* are the means of the preservation of the species when the water, as is always the case in the shallow hollows in stones, their natural station, is dried up for a long time and all the living inhabitants are precipitated on the stone. The observations of Major von Flotow have already demonstrated that the dried-up muddy sediment always reproduces *Stephanosphæræ* when water is again poured on to it. This *capability of reviving from the dried condition* is shared by *Stephanosphæra* with *Chlamydococcus pluvialis*, in which likewise the motionless cells remain living after being dried up for years, and are capable of giving birth to moving forms, while the swarming-cells themselves are destroyed for ever by rapid desiccation. Herr von Flotow has sent earth with dried *Stephanosphæræ* to Dr. Rabenhorst in Dresden, who, in like manner, succeeded in reviving them by moistening.

"Since the moving *Stephanosphæræ* are destroyed, just like the swarming-cells of *Chlamydococcus*, by rapid desiccation, I believe that the motionless Protococcoid globes, the development of which I have just described, are the forms which do not lose their vitality by drying, but are capable, when wetted again with water, of going through a cycle of development, by which they return to the normal moving form of *Stephanosphæra*. Yet I must remark that I have not hitherto obtained sufficient material to observe the resting *Stephanosphæra*, and to trace the processes which occur in the revivification.

"Respecting their vital manifestations, repeated experiments showed that *the moving spheres of* Stephanosphæra *seek the darker part of the vessel, avoiding however a total absence of light, and assembling in preference in a moderated light or half-shadow.* Since other Algæ and Infusoria exhibit a different behaviour towards the light, we thus possess a means of *sorting*, to a certain extent, the microscopic inhabitants of a specimen of water, as I did the shade-loving *Stephanosphæræ* from *Chlamydococcus*, which ordinarily seek the brightest light."

An important appendix to this history of *Stephanosphæra* has quite recently appeared from the joint labours of Professor Cohn and Wichura (*Nov. Act. Acad. Curios. Naturæ*, 1857, Part I.), and has been translated into English by Mr. Currey (*J.M.S.* 1858, p. 131).

The resting-stage above spoken of is again referred to concisely and clearly in this paragraph:—"Under certain circumstances each of the eight cells secretes a cellular covering, and swims about in the interior of the globe in the form of free *Chlamydomonas*-like cells (XIX. 44); eventually they escape, either by fissure of the globe, or by its gradual dissolution, lose their cilia, form a thicker membrane, become motionless, and accumulate at the bottom of the vessel. If the vessel be then permitted to become thoroughly dry, and afterwards be again filled with water, motile *Stephanosphæræ* reappear, from which it seems probable that the green globes are the resting-spores of the plant." These, it may be added, are with difficulty, if at all, distinguishable from those of *Chlamydococcus pluvialis*: they vary very much in size, and apparently grow after entering on the state of rest. Their colour is deep green (occasionally yellowish or olive); and they have a nucleus, and frequently a nucleolus. We cannot do better than copy Mr. Currey's abridged translation, in endeavouring to convey the results arrived at by Cohn and Wichura:—

"When the water is permitted to evaporate gradually, the resting-cells become yellow, and afterwards orange or red, and their contents have a more oily appearance. The authors found that if the water was not permitted to evaporate, the resting-spores, although continuing to live, did not become developed into *Stephanosphæræ*; but when fresh water was poured upon desiccated resting-spores, twenty-four hours sufficed for the production of motile *Stephanosphæræ*.

"The following is the process of transformation from the state of rest into the motile form.

"The dried resting-spores take up the water, and their contents (hitherto somewhat misshapen) gradually fill up the cavity of the containing membrane, and become cloudy and granular; the border becomes yellowish, and the red colouring matter is concentrated in the centre. The cells then begin to divide; and the successive forms assumed in this process will be better understood by reference to XIX. 44–47, than by description. In passing from the state shown in fig. 45 to that shown in fig. 46, the outer membrane has gradually become invisible. Up to fig. 47 the process has occupied about two hours. The four daughter-cells (fig. 47) begin to quiver, and to endeavour to separate from one another. Two cilia are now perceptible at the pointed extremity of each of the four cells, by the action of which the group begins to move as a whole, and in a laboured manner, in the water; ultimately, however, all trace of the enveloping membrane and of the glutinous connecting substance disappears, and one by one the daughter-cells escape and become free. Figs. 48 and 49 exhibit different forms of these free daughter-cells, which contain two, three, or several granules (amylon ?) and sometimes also vacuoles. The sharp end is often prolonged into a colourless beak. At this period there is no proper cellulose membrane. At the moment of escaping, their diameter never exceeds 0·010 mm.; but they soon enlarge and attain a diameter of 0·013 to 0·015 mm.

"Their form and the length of the beak are variable, the latter being sometimes altogether wanting. In form and motion they resemble exactly the naked primordial-cells, which are produced by division from the resting-cells of *Chlamydococcus pluvialis*. The authors have never seen the resting-cells of *Stephanosphæræ* divide into more than four parts, but think it not improbable that division into a greater number (eight or possibly sixteen) sometimes occurs.

"The length of time which elapsed between the immersion of the dried resting-spores and the first appearance of the motile cells varied from nine to twenty-four hours. It was noticed that those resting-spores which did not produce zoospores within six days never did so afterwards, although they continued to live and were perfectly healthy.

"Zoospores, produced in the month of November, did not advance beyond the first stage (fig. 49). Others, however, produced in March, remained only a few hours in that condition, after which time a delicate membrane was formed round the body of the primordial cell (XIX. 50); this membrane was at first closely attached to the primordial-cell, but became gradually enlarged by absorption of water into a colourless enveloping vesicle (figs. 50, 54), usually globular but sometimes oval, having two openings, through which the cilia penetrate. In this condition they attain a diameter of 0·017–0·022''', and are not distinguishable from encysted forms of *Chlamydococcus pluvialis.* Other zoospores, produced on the 1st of April, 1857, attained a larger size; and the protoplasm of the primordial cell, instead of retaining its continuous outline, became elongated here and there into simple or forked mucilaginous rays, which were either colourless or green from the presence of chlorophyll (fig. 53). These rays are probably produced by the protoplasm adhering at certain points to the surrounding membrane, and being carried outwards by its growth.

The *Chlamydococcus*-like form only lasted a few hours: towards the evening the zoospores mostly began to divide. In the first place, the protoplasmic rays are drawn in, and the primordial cell becomes round; it then elongates itself in the direction of an axis passing through the point of origin of the cilia, and by the process of division assumes the forms shown in figs. 54 and 55. This state is usually attained by about nine o'clock in the evening; and about eleven o'clock a constriction commences in a plane at right angles to the former plane of division; and eventually the primordial cell is divided into quadrants, each containing a nucleus and a portion of the red substance. The two cilia, which have retained their activity, originate in the interspace between two quadrants. About midnight usually, but sometimes earlier, constriction recommences, and the form in fig. 56 is attained. This constriction proceeds towards the middle point of the spheroid, by which the quadrants are bisected, and ultimately divided into eight wedge-shaped portions, whose contour-lines, like the spokes of a wheel, meet in the middle.

"And now commences a further process of development, which forms the ground of the generic distinction between *Stephanosphæra* and *Chlamydococcus.* For, whilst in *Chlamydococcus* the individual portions of a primordial cell separate entirely from one another, each developing its own enveloping membrane, and ultimately escaping as a unicellular individual, in *Stephanosphæra*, on the other hand, the eight portions remain united as a family. The coloured contents of the individual portions become drawn back towards the periphery in a centrifugal direction, a colourless plasma remaining about the central point; this disappears at first in the centre; a cavity is formed in the middle of the disk; and as this enlarges, the eight portions assume the form of a wreath, consisting of eight globular or ellipsoidal bodies in close contact (fig. 57), and usually not exactly in one plane, owing to the outer membrane not having expanded in proportion to the enlargement of the plasma. The original cilia continue active, causing the motion of the whole organism, until the eight portions are completely individualized; and then their motion ceases: but at this period each of the eight parts may be seen to be provided with two cilia, which are in motion so far as their limited space allows.

The separate parts of the plasma now form eight independent but closely-packed membraneless primordial cells. Shortly afterwards it is seen that a delicate membrane, common to them all, has been secreted beneath the mother-cell membrane, round the disk formed by the primordial cells; this membrane at first lies in close contact with the latter cells, following the constrictions of the disk, but afterwards becomes further and further removed as it swells and tends to assume a globular form (fig. 58). By the motion of the cilia the mother-cell membrane is gradually thrown off, and the young family escapes into the water. Its eight green primordial cells still enclose the last traces of the red substance, which gradually disappears, and instead of which are seen two granules; the primordial cells are in immediate contact at the sides, and are of an oval or globular shape; their common enveloping membrane is at first constricted at the border following the outline of the primordial cells; it eventually becomes globular, although continuing for a long time much flattened at the poles, in the form of a disk-shaped spheroid. When the *Chlamydococcus*-like unicellular *Stephanosphæra* has commenced its division early in the evening, the division into eight is perfected during the night, and early in the morning the young family quits its cast-off mother-cell membrane.

"In the course of the day the individual primordial cells, and their common enveloping membrane, grow until the latter attains a diameter of 0·040-0·048'''. During this growth the shape of the primordial cells is changed by the formation of various prolongations in the manner above described: but in the course of the afternoon the primordial cells again become round; and during the evening, division commences in them precisely similar to the process in the unicellular *Stephanosphæra*: on the following morning we find eight young families, with the common enveloping membrane, which soon escape and go through the same process. It is calculated that in eight days, under favourable circumstances, 16,777,216 families may be formed from one resting-cell of *Stephanosphæra*. It is remarkable that the division of the primordial cells in *Stephanosphæra* is confined to a certain time of day: it begins towards evening, and is completed the following morning. In the observations made in Lapland, at a time when the daylight there lasted during the whole night, the beginning and end of the division were observed to take place at almost the same hours as in the observations made at Breslau in the spring, when the day and night were almost of equal length. Sometimes the division ceases after the formation of only four primordial cells. On one occasion the authors observed a family with only three cells, one only of the two halves first formed having undergone a second division. In Lapland a family with sixteen cells was once observed.

"The authors then proceed to discuss the nature of the resting-cells in *Stephanosphæra* and *Chlamydococcus*, and come to the conclusion that they are not *spores*; *i. e.* that they are not of the same nature as the red cells of *Œdogonium*, *Bulbochæte*, *Draparnaldia*, *Chætophora*, *Sphæroplea*, *Volvox*, &c.

"They come to this conclusion upon two grounds: 1st, that the resting-cells in question continue to grow after becoming quiescent; and secondly, that it is probable (although not yet proved) that the resting-cells increase by self-division, thus producing new generations of resting-cells. These two characteristics the authors consider inconsistent with the idea of a spore.

"In conclusion, the authors notice the formation of microgonidia in *Stephanosphæra*, which takes place by the division of the primordial cells into numberless small portions. Fig. 5 shows a *Stephanosphæra*, in which seven of the eight primordial cells have formed microgonidia; the individual microgonidia (fig. 52 *a*, *b*, *c*) become free by the disintegration of these eight groups into their constituent portions. The authors think it not improbable that the microgonidia exercise an impregnative influence in spore-formation, but admit that there is no evidence to prove it."

Mr. Currey (*J. M. S.* 1858, p. 209) reopens the question concerning the nature of the red resting-cells of *Stephanosphæra*, and argues against the conclusion drawn by Cohn and Wichura. He says those observers have noticed "that these cells in *Stephanosphæra pluvialis*, which are at first of a green colour, and furnished with cilia, increase in growth after the green colour and the cilia have disappeared, *i. e.* after they have assumed a state of rest, a fact which they consider to militate against their character as spores.

"'We have seen,' they say, 'that these resting-cells, after they have been formed by the metamorphosis of a motile primordial cell, increase in growth considerably, that they go through a further vegetative development, and have, therefore, not reached the termination of their vital process.' And they then add—'It is contrary to the idea of a spore, that it should continue to grow after having assumed the character of a resting-cell; and the fact has never yet been observed in any single case.' It would seem that these remarks are intended to be limited to the Algæ; but it is worthy of observation, that the spores of the ascigerous Fungi frequently increase in growth after escaping from the asci; and if this circumstance is not to be looked upon as affecting their character as spores, it is difficult to see why a different rule should be applied to the Algæ.

"Cohn and Wichura moreover consider that the increase by self-division is irreconcileable with the idea of a spore. In speaking of the red cells of *Chlamydococcus pluvialis*, they express a doubt whether in those cells increase by self-division takes place, but assert that, if such should prove to be the case, it would be conclusive against their being spores, considering self-division (if I understand them right) to be a process of vegetative development distinct from germination. These observations are worthy of the careful attention of microscopists; and without venturing an opinion as to their correctness, I would only remark, that if the resting-cells of *Chlamydococcus* and *Stephanosphæra* are not to be considered spores, that character must also be denied to the resting-cells of *Œdogonium*, *Bulbochæte*, *Draparnaldia*, *Sphæroplea*, and *Volvox*, if, as is more than probable, there should be detected in these latter cells, 1st, an increase in growth after becoming quiescent; or, 2dly, increase by self-division."

VOLVOX (XX. 32–49).—This genus has always been an especial favourite with microscopical students. Its colonies of numerous monadiform green bodies distributed over the surface of miniature globes, endowed with active motion, revolving hither and thither, form one of the most pleasing objects that the microscope can display. Moreover, the more minutely the globes of the *Volvox* are examined, the more interest do they awaken, by reason of the regularity and beauty of their intimate structure, and of the results of their vital processes.

The consequence of this has been a host of observers and writers on the anatomy and physiology of *Volvox*, and a formidable array of conflicting views on those topics, the consequence of careless and insufficient research, of indifferent instruments, and of the influence of fanciful hypotheses. We shall, however, attempt no analysis of the many accounts of *Volvox* in existence, but restrict ourselves to an abstract of the more recent important observations and conclusions of Professors Williamson and Busk, particularly of the former and earlier observer on that organism, premising it by a brief notice of Ehrenberg's views.

Formerly the whole globular mass was regarded as a single warty and ciliated animalcule; and the act of bursting, whereby the smaller globes developed within it which had reached maturity were liberated, was considered to be the birth of young animals. This theory Ehrenberg clearly proved to be erroneous, and showed that, to use his language, the supposed spherical animalcule was in reality a colony of monad-like beings distributed over the inner surface of a common lorica, and connected together by filiform cords or tubes; in other words, he proved each sphere or globe to be, if we may so term it, a hollow cluster of many hundreds or even thousands of living occupants, and to frequently contain within it other smaller hollow spheres, similar in nature to itself, and in fact developed from it by a process of self-division. The result of these considerations led Ehrenberg to perceive the true homology between the spheres of *Volvox* and the four-sided tablets of *Gonium*.

Each member of the colony, he added, has an individuality of its own, and to all appearance resembles an ordinary simple monad, enclosed within a lorica (a *lacerna*), having a red eye-speck, a double filiform proboscis or filament protruding from the surface of the common spherical lorica and giving the hairy or ciliated appearance to it, and at the base of these filaments a mouth, indicated by a bright, clear spot. Internally Ehrenberg believed he discerned clear digestive cells, a contractile seminal vesicle, one or two round sexual glands, and numerous green ova. The following history of *Volvox* conveys the present state of information and opinion on this interesting organism.

The globes of *Volvox* are bounded externally by a hyaline structureless membrane or pellicle, which corresponds to the "envelope-cell" as understood by Cohn (XX. 34, 45). Distributed on the inner wall or surface of this membrane, is (in Cohn's words *J. M. S.* 1857, p. 140) "an infinitude of very minute hexagonal cells, attached to each other in the same way as are the elements of an epidermic tissue" (XX. 38). The protoplasmic matter or the endochrome of each cell constitutes the presumed monad of Ehrenberg, which is flask-shaped, and protrudes its tapering extremity or neck outwards, bearing at its apex two ciliary filaments which penetrate the common envelope and vibrate freely in the surrounding water.

The green substance composing each monadiform individual or "primordial cell," is the usual vegetable protoplasm, and contains chlorophyll-vesicles, a clear globule or nucleus, one or rarely two contractile vesicles, and usually a brownish-red speck, regarded by Ehrenberg as a visual organ (XX. 35); the filaments are, as usual, productions from the protoplasm. Further, each green globule is enveloped in one or more partially organized special membranes, which are in more or less close apposition with it according to the age and the conditions of life under which the *Volvox* is placed (XX. 35, 37), and give it the essential characters of a cell with a cell-wall. In the early stage of development the several protoplasmic masses in a colony are closely aggregated; but as age advances, a clear interval surrounds and separates them, traversed by several prolongations of the protoplasmic matter connecting together adjoining cells (XX. 37). These processes extend outwards like so many rays from each primordial cell, and as a rule encounter those from surrounding cells at a determinate distance, where they meet with an external, delicate, transparent membrane—the wall of the cell of which the central green globule represents the nucleus. This thin membrane forms the boundary of each clear space surrounding the contained green globule; and from the mutual pressure of the assemblage of cells composing the *Volvox*, it acquires, as seen from above, a hexagonal figure (XX. 38, 39-41, 45).

We have observed already that, as age advances, the space or areola around each primordial cell increases; that is, the external cell-wall becomes further detached from the contained protoplasmic mass, and hence the processes connecting the two—at first, and even for some considerable time during active nutrition, thick, clumsy, and irregular (XX. 42, 43)—become gradually stretched, until they are eventually converted into attenuated threads or almost imperceptible lines. In fact, by over-distension of the cells from any cause, whether, as commonly happens, from advancing age, or from the breaking up of the globe, these cords get ruptured, and then, by retracting themselves from the outer delicate cell-wall, coalesce with the protoplasmic central mass. On comparing this structure with that of *Gonium* as recorded by Cohn, a close homology is perceptible. In this plant the membrane surrounding the hexagonal primordial cells gives off from each angle a tubular process, which comes into intimate apposition at its extremity with that from an adjoining cell. However, between these processes of *Gonium* and those of *Volvox*, there is this difference, that in the former it is only the primordial membrane which is drawn out to form a canal or tubule, whilst in the latter the protoplasm itself is at first extended with its membrane, and subsequently collapses into a delicate band.

The circular contractile vesicle noticed by Ehrenberg has had its existence confirmed by Mr. Busk in mature cells (*T. M. S.* 1852, p. 35):—"It may be situated in any part of the zoospore (XX. 35), not unfrequently in the base, or even in the midst of one or other of the bands of protoplasm connecting it with its neighbours; it is pretty uniform in size, and about 1-9000th of an inch in diameter." Its most curious property is its rhythmical contractility, its pulsations occurring very regularly at intervals of about 38″ to 41″. The contraction is rapid, whilst the dilatation is gradual." The vesicle "would seem to exist, or at all events to present a contractile property only for a limited period, and to disappear soon after the formation of the brown spot," *i. e.* the eye-speck. The coloured eye-speck or stigma lies close against the primordial-cell wall, it is not invariably present, and consequently cannot be esteemed of essential importance as a characteristic.

The wall of a *Volvox* has an appreciable thickness, represented by a vertical section—in fact by the depth of the cells, which are placed side by side, the lines of junction being straight and perpendicular to the external surface of the globe (XX. 36). The inner sides of the cells, bounding the internal cavity of the globe, are somewhat convex, the result of mutual lateral pressure, and the absence of centrifugal pressure. Prof. Williamson has well displayed this by sectional diagrams taken from his preparations. These sectional views also demonstrate the position of the rounded masses of green protoplasm—the primordial sacs—to be immediately on the inside of the peripheral membrane or envelope-cell of the *Volvox* (XX. 37, 38).

Development of Volvox.—Self-division of the primordial cells, or zoospores (Busk), of *Volvox* is regulated by the same laws that prevail in other *Volvocineæ* and in other unicellular Algæ in general. Among the younger specimens of *Volvox*, one or more larger globules are observable (XX. 42-44), which, if watched, will be found to undergo segmentation, first into two (XX. 42), then into four portions (XX. 43), and so on (XX. 46), always keeping to the power of two and its multiples, until some hundreds of minute corpuscles are developed (XX. 47), which, according to the nature of the genus, so dispose themselves in a lamina as to enclose a hollow spherical space, and to assume the characteristic globular form. Thus a new *Volvox* is generated, but differing from mature forms in the contiguity of its component individuals,—a difference, however, which progressively vanishes with advancing age. The young globe lies immediately within the parent being, to which for a time it adheres, as it would seem, by means of a delicate capsular membrane, within which its development has proceeded. This indeed forms its sole bond of union with the common envelope of the parent *Volvox* (XX. 33).

When first formed, the cilia of the primordial cells do not penetrate through the external envelope of the young globe: however, this condition is of short duration; for no sooner is the detachment from the wall of the parent about to supervene, than the cilia protrude externally, and, commencing their vibratile movements, soon set the newly-developed colony in motion within the cavity of its parent. The detachment is consequent on the rupture of the investing capsule, caused, no doubt, by the constantly enlarging bulk of the young organisms. Constantly several young colonies are developed from the parent at the same time, or nearly so, by the self-fission of various primordial cells; hence, as a rule, a brood of young globes is to be seen revolving within the parent sphere (XX. 33), from which ere long it is released by its rupture.

The condition of the individual cells of a young *Volvox* has already been mentioned,—viz. their close apposition at first, their gradual separation by an interval, the appearance of radiating processes from the protoplasm, and their progressive attenuation. To this account we may add that contiguous intercurrent processes, in their earlier stages, appear to coalesce,—a circumstance which indicates that the protoplasm is then unenclosed by a pellicle or envelope. Again, the protoplasm gradually contracts itself into its flask-shape, the retraction and coalescence of its processes being a simultaneous phenomenon; indeed contraction of the protoplasmic globules advances continuously until, as in old specimens, only a small rounded mass appears in the centre of a large clear space. Lastly, the coloured stigma is an after-production; and its advent would seem to indicate the maturity of the cell.

Analogy with other *Volvocineæ* would lead us to look for a quiescent or "still" stage of the cells of *Volvox*, and the formation of microgonidia, in addition to the process described, viz. multiplication by self-division with the production of macrogonidia. That a "still" form actually occurs is pretty clearly shown by Mr. Busk's observations of *Volvox aureus*, from which this presumed species appears to be nothing more than *Volvox globator*, having a varying number of its cells encysted to form the winter or "resting" spores. The primordial cells which are to undergo this change are at first indistinguishable from the ordinary ones, except in having a deeper green colour (*Busk*, *op. cit.* p. 38). Afterwards, however, they acquire a thick wall, change to a yellow colour (hence the appellation *aureus*, golden or yellow), without material alteration of size, and produce a second equally firm and distinct envelope; or rather, it may be, the original cells contract somewhat, and then form a second coat around themselves. Eventually a considerable space exists between these two coats, occupied by a clear and apparently aqueous fluid; but upon the addition of a solution of iodine, a granular cloudiness is produced in it. The contents of the inner cell consist chiefly of amylaceous grains, mixed with a greenish material in the one case, and with a bright yellow, apparently oily fluid in the other. The amylaceous particles are of an irregular botryoidal form, and far from uniform in size.

Mr. Currey, in a recent interesting communication on fresh-water Algæ (*J. M. S.* 1858, p. 208), states that he has seen "one of the large, orange-coloured spores of the so-called *V. aureus*, which is only the resting form of *V. globator*, where the contents divided into five globular colourless cells, which floated in a mass of reddish plasma, being apparently the remains of so much of the original contents of the cell as had not been absorbed in the formation of the secondary cells."

Of the *Volvox stellatus*, Mr. Busk adds that it seems to him merely a modification of *V. aureus*, and appears to follow the same course of change, and doubtless of future development. With these conclusions Prof. Williamson coincides, and remarks (*op. cit.* p. 56) that "the ordinary power of gemmation in *V. stellatus* appears to have worn itself out, since, though the gemmæ often exist with the spores (?), they are small, colourless, and abortive."

It must also be mentioned that Perty suggests an analogous interpretation of the nature of *Volvox aureus*, and doubts likewise the specific importance of *V. stellatus*.

Since the above remarks were penned, Cohn's researches on *Volvox globator* have determined the reality of another mode of reproduction besides fission, as surmised (*Ann. Sc. Nat.* and *Comptes Rendus*, 1856). The abstract of this most interesting paper is translated in the *J. M. S.* 1857, p. 149 :—"The second mode of reproduction of *Volvox* requires a sexual conjunction, and is not observed indifferently in all individuals. The spherules endowed with the sexual function are distinguished by their volume and the more considerable number of their component utricles: they are generally monœcious; that is to say, they enclose at the same time male and female cells, although the majority of their contents are neuter. The female cells soon exceed their neighbours in size, assume a deeper green colour, and become elongated like a matrass towards the centre of the *Volvox*. The endochrome of these cells does not undergo fission. In other cells, on the contrary, which acquire the size and form of the female cells, the green plasma may be seen to divide symmetrically into an infinity of very minute particles, or linear corpuscles, associated into discoid bundles. These are furnished with vibratile cilia, and oscillate at first slowly in their prism; but the movement soon becomes more active, and the bundles speedily break up into their constituent elements. The free corpuscles are very agile, and it is impossible to regard them as anything but true spermatozoids; they are linear and thickened at the posterior extremity; two long cilia are placed behind their middle, and the rostrum, which is curved like the neck of a swan, possesses sufficient contractility to execute the most varied movements. These spermatozoids, so soon as they are they are able to disperse themselves in the cavity of the *Volvox*, quickly crowd around the female cells, into which they eventually penetrate; arrived there, they attach themselves by the beak to the plastic globule, destined in each cell to form a *spore*, and with which they are gradually incorporated. Fecundation having been thus effected, the reproductive globule becomes enveloped successively by an integument exhibiting conical pointed eminences, and by an interior smooth membrane; the chlorophyll which it contained is now replaced by starch grains, and a red or orange-coloured oil. This is the condition of the spore at maturity; and occasionally forty of these bodies may be counted in a single globe of *Volvox*. The germination of these reproductive bodies has not yet been observed, so that their history cannot be regarded as complete; but from analogy it may in the meanwhile be assumed that they germinate in the same way as do the spores of *Œdogonium*, *Sphæroplea*, and other Algæ belonging to the same order. It may be maintained, moreover, as certain that the *Sphærosira volvox*, Ehr., is nothing else than a monœcious *Volvox globator*; that his *Volvox stellatus* is also *V. globator*, observed at the time when it is filled with stellate spores; and lastly, that his *V. aureus* differs from the other forms of the same species, simply in the smooth [and coloured] condition of the spores."

FAMILY IV.—VIBRIONIA.

(Plate XVIII. 57 to 69.)

This family follows, in Ehrenberg's system, the *Volvocineæ*; yet, by reason of the extreme simplicity of structure of the beings composing it, it should, in any attempted natural system, be placed even below the *Monadina*.

The distinguished author of the *Infusionsthierchen* attributed an animal nature to the *Vibrionia*, and although obliged to confess his inability to detect any internal organization, nevertheless argued, from analogy, that a polygastric structure was to be presumed, and that their movements were voluntary, and of themselves sufficient proof of animality. In *Bacterium triloculare*, indeed, Ehrenberg believed he saw an internal granular ova-mass, a vibratile filament, and spontaneous fission. Of the *Vibrionia* generally, he stated that they were unable to change the form of their body, although without lorica, and that by imperfect self-division they formed chains or concatenated filaments, which in *Spirillum*, from the obliquity of the junction-surfaces of the component *Vibrios*, assume a spiral form.

Various later writers, among whom are Leuckhart, Cohn, and Burnett, would transfer the *Vibrionia* to the vegetable kingdom. The last-named author contributed a valuable paper to the American Association in 1850; but the most recent examination of the nature and structure of the beings in question is from the able pen of Dr. Cohn (*Entw.*). We must also mention that Perty has given considerable attention to the *Vibrionia*, and contributed some original observations. It is to Cohn's account, however, that we shall chiefly resort in our attempt to describe the minute and curious members of this family, which, if not rich in genera, is unsurpassed by any in the abundance and diffusion of its members.

Some naturalists have considered the *Vibrionia* to be the active agents in producing putrefaction, since they are invariably found in decomposing fluids, just as the yeast-plant (*Torula*) always occurs in fermenting saccharine matters and appears to excite the process of fermentation.

The *Vibrionia* are for the most part colourless; under certain conditions, however, they assume a yellow, red, or a blue tint, but never a green colour. Their movements, says Perty, are rapid and energetic, so much so that the corpuscles of *Hysginum nivale*, although at least one thousand times larger, are thrust aside by *Bacterium Termo* when in motion. They can advance with either end forward with equal facility, and mostly seem, after proceeding a certain distance, to retrace their course to the point they started from.

The extreme minuteness of some *Vibrionia* may be conceived from the statement of Perty, that, according to his calculation, four thousand millions occupy no more space than one cubic line.

Dujardin, who retains the *Vibrionia* among animalcules, makes the following remarks:—"The *Vibrionia* are the first Infusoria which present themselves in all infusions, and which from their extreme smallness, and the imperfection of our means of observation, must be considered the most simple; ......for it is only their more or less active movements which lead to their being regarded as animals at all. I have been sometimes induced to believe that there is a flagelliform filament, analogous to that of monads, or rather perhaps a spiral undulating one, which produces the peculiar mode of locomotion. Is the *Bacterium triloculare*, described by Ehrenberg as having a proboscis, a true *Vibrio*?

"All that can be with certainty predicated respecting their organization is that they are contractile, and propagate by spontaneous fission, often imperfect in character, and hence give rise to chains of greater or less length."

Cohn modestly premises (*Entw.* p. 118) that his researches have been directed chiefly to one species; yet, from scattered observations, and from presumptive evidence, he would assign a vegetable nature to all the species.

In decomposing infusions, often after a few hours, extremely minute corpuscles may be seen in countless number, having the figure of a dot or comma, or of very delicate lines with the ends somewhat thickened. Their motion is tolerably active, darting hither and thither, contorting themselves at the same time by a rotating movement upon their long axis, and, when in masses, produce the appearance of a ceaseless swarming, in which the individual specks are easily overlooked on account of their smallness. They, however, differ in size among themselves, varying from 1-2000 to 1-700''' in length. Ehrenberg attributed to this world-wide form the name of *Vibrio* *lineola*, whilst Dujardin more correctly separated it from the Vibrios under the name of *Bacterium Termo*. Under this latter appellation Perty has also described it.

Now when we come to examine an infusion rich in these organisms, numerous jelly-like colourless masses of different size and figure (XVIII. 69) may be met with on the walls of the vessel, and on the surface of the fluid. These when young resemble small balls, from 1-100''' and less in diameter; but as they continue constantly to enlarge, they acquire a clustered outline, and exhibit themselves as colourless masses and films of very considerable superficial dimensions and thickness, resembling soft Palmellæ in consistence. Like these they are composed of a transparent mucus, in which numberless punctate or linear corpuscles are imbedded. These last are identical with the isolated particles known as *Bacterium Termo*. That these corpuscles are held together by the common mucus, is evident to the eye; even the largest films are also composed of globular clusters agglomerated together, the outline of the gelatinous mass appearing sharply defined in the water. Moreover, the linear corpuscles appear more thickly congregated at the periphery than in the centre of the spherical collections; but this is an optical delusion. Again, when colouring matter is added to the water, the *Bacterium*-mucus is not tinged by it; and when any passing Infusorium impinges against it, its surface is pressed in; and lastly, the absence of an independent and inherent molecular motion among the particles show them to be enclosed within a resistant medium. Frequently, whilst under observation, single corpuscles may be seen to detach themselves and swim away in the characteristic manner.

The definite outline and figure of the mucilaginous globules, and of their clusters, refute the notion that such are merely collections of dead *Bacterium*-corpuscles. The indication is rather that the *Palmella*-like masses represent the young condition of *Bacterium*; indeed, the same cycle of development proceeds as in *Palmella, Tetraspora*, and allied forms. . . . The only difference betwixt the *Bacterium*-heaps and *Palmella*- or *Tetraspora*-masses is, that in the first the individual corpuscles are so minute that the characters of simple cells cannot confidently be assigned them, and that, instead of being yellow or light green, they are quite colourless. Nevertheless, in Kützing's *Palmella Brebissonii* and *P. hyalina*, the cells are only 1-3000 to 1-1000''' in length, whilst their figure and distribution are indistinguishable from *Bacterium*. The absence of colour is a feature of the Fungi connected with their occurrence in decomposing infusions; yet *Palmella hyalina* has only a pale ochreous hue, and Cohn seems to satisfactorily establish that the mere presence or absence of colour cannot constitute that decisive character which the separation of the microscopic Fungi from the Algæ implies.

From the above it appears evident that the corpuscles known as *Bacterium Termo* are the swarm-cells (zoospores) of a plant allied to *Palmella* and *Tetraspora*, but referable, by reason of the want of colour, to the microscopical aquatic Fungi. When these *Vibrios* pass into a state of rest, they accumulate on the surface of the water in the form of films, &c., as do the resting-spores of *Tetraspora, Stigeoclinium, Conferva*, and other Algæ, but, unlike these, are connected together by an intercellular substance, within which their growth proceeds, and leads frequently, as Perty has illustrated, to their disposal in linear branching series.

From the analogy with *Tetraspora* and the other swarm-cells of Algæ and Fungi, it must be assumed that the *Bacterium*-corpuscles move by means of a vibratile fibre; indeed Ehrenberg intimates having seen a filament in *Bacterium triloculare*, and Dujardin considered some such mechanism probable.

The growth of the mucous balls is the consequence of the constantly repeated transverse fission of the *Bacterium*-bodies, and is exceedingly rapid. Von Flotow seems to have detected the compound masses, and named one such *Microhaloa teres*; but Cohn finds it necessary to create a new genus, which he has named *Zoogl[oe]a*.

Of the remaining *Vibrios*, Cohn has not as yet complete researches; yet he finds sufficient support from analogy to warrant him in assuming a like history for them as for *Zoogl[oe]a*. The larger forms of *Vibrio* have (he says) a striking affinity with the *Oscillariæ*, whilst the longer, slowly-moving species have a very great likeness to the shorter fibres of *Hygrocrocis*, from which, some have stated, *Vibrios* derived their origin. The affinity of *Vibrio* with the colourless *Oscillariæ*—with the genus *Beggiatoa*, in which also very delicate forms occur—may be especially pointed out; but this affinity is yet more striking with *Spirillum* and *Spirochæta*, the other two genera of *Vibrionia*. Further, in Oscillarieæ we meet with straight species, *e. g. Oscillaria*, and spirally convoluted forms, *e. g. Spirulina*, just as we have straight forms in *Vibrio*, and spirally-twisted ones in *Spirillum* and *Spirochæta*. Likewise, on comparing the movements of *Spirochæta* with those of *Spirulina*, we find no distinction between them except in energy and liveliness.

The results of his examination of *Vibrionia* are thus summarily stated by Cohn (p. 130):—

"1. The *Vibrionia* apparently all belong to the vegetable kingdom; for they exhibit an intimate affinity with undoubted Algæ.

"2. By reason of their want of colour, and their occurrence in decomposing infusions, the *Vibrionia* belong to the group of aquatic fungi (*Mycophyceæ*)." Cohn, however, shows good reason for not admitting this as a natural group distinct from Algæ.

"3. *Bacterium Termo* is the motile swarming-phase of a genus, *Zoogl[oe]a*, allied with *Palmella* and *Tetraspora*.

"4. *Spirochæta plicatilis* belongs to the genus *Spirulina*, of which it must be at once admitted as a species (*Spirulina plicatilis*).

"5. The long *Vibrios* which do not coil (*Vibrio Bacillus*) arrange themselves with the more delicate forms of *Beggiatoa* (*Oscillaria*).

"6. The shorter *Vibrios* and *Spirillæ* resemble indeed, in form and character of motion, the *Oscillariæ* and *Spirulinæ*; nevertheless I cannot positively decide on their true nature."

To this abstract of Cohn's paper on *Vibrionia* we must add a notice of Dr. Burnett's essay, which is equally in favour of their plant-like nature. The chief observations and opinions of Dr. Burnett are—that a branching of the chains, similar to that of the ordinary forms of Algæ, is observable in *Vibrionia*, particularly in *Spirillum*; that, on watching their gradual growth, the smaller seem no other than the younger forms of larger species (for instance, that *Vibrio* is the first condition under which *Bacterium* and *Spirillum* appear); that besides self-division, propagation is effected by budding, a fact further exemplified by the occurrence of ramifications; and that in young forms a nucleus is absent, although one becomes apparent in advanced stages. Again, as to the movements of *Vibrionia*, Dr. Burnett can see no further indication of movement in them than in spermatozoa and in vegetable cells, like which they are unaffected by electrical shocks, which are fatal to the lower forms of animal life.

"Their cell-structure and their vital (not voluntary) motion would then lead us to infer that the *Vibrionia* are Algous plants, and not animals. This throws light on several common phenomena. One in particular is, that the *Vibrionia* should almost invariably be found in infusions and liquids that contain other Algæ, and especially the common *Torula*; for I do not remember to have seen the *Torula* without *Vibrionia*."

Perty moreover testifies to *Vibrio Bacillus* assuming a still condition, and, by its branching concatenation, a plant-like form, out of which are constructed masses and films in the infusion and upon its surface, resembling *Hygrocrocis* and other Algæ and aquatic Fungi.

Dr. Ayres (*J. M. S.* i. p. 301) contributes the following observations on the self-division of the *Vibrionia*:—" While," he writes, " the shortest of the *Vibriones* were in active motion, the longer ones were comparatively quiescent; and these exhibited, according to their length, from one to six transverse lines, indicating the points of separation in the reproductive process. Those of moderate length, presenting only one or two transverse lines, were rather active, and often bent at an angle at the transverse lines, which presented the appearance of separation into two distinct individuals; and the character of the movements appeared such as to favour the separation. Those with from three to six transverse lines were, for the most part, quiescent. I imagined, although from their excessive minuteness and transparency this was not plainly and unequivocally discernible, that there were indentations of the extremities of the transverse lines, by which constrictions were produced, which, by their increase, would finally effect a complete transverse division of the animals."

The occurrence of *Vibrios*, or at least of *Vibrio*-like forms, as one of the metamorphic phases of the *Phytozoa* of the antheridia of *Characeæ*, e.g. *Marchantia*, has been mentioned in a foregoing page (126), to which we must refer our readers.

FAMILY V.—ASTASIÆA OR EUGLENÆA.

(Plate XVIII. 36—50, 52, 53, 55, 56.)

Dujardin very properly prefers to call this group *Euglenæa* (*Eugléniens*), on account of the resemblance in sound of the first name with that of *Astaciæa* (*Astaciens*) used to designate a family of the higher Crustacea.

In Ehrenberg's system it constituted a family of the Polygastrica, and was characterized by wanting a true alimentary canal, a lorica and appendages, and by having a mouth surmounted by one or two proboscides, and in most species by a changeable form. Internally, digestive sacs, ova, a seminal gland, and contractile vesicle, and in most genera one or more red specks or eyes, were represented as present. The genera included were—*Astasia*, *Amblyophis*, *Euglena*, *Chlorogonium*, *Colacium*, and *Distigma*. The value of these genera has been called in question by various writers. Dujardin makes the variability of form—in other words, a contractile integument—a leading feature, and rejects the eye-speck as neither distinctive nor constant; consequently he excludes from the family the *Euglenæ* with rigid integument, and transplants them to the *Thecamonadina*, and rearranges the remaining species according to the number, disposition, and character of their locomotive filaments. Likewise Schneider (*A. N. H.* 1854, xiv. p. 327) separates *Chlorogonium* from the *Astasiæa* because of its unchangeable figure; and Mr. Carter (*A. N. H.* 1856, xviii. p. 116) would also detach *Astasia* from *Euglena*, from the conviction that the former has an animal organization, and that the latter is referable to plants.

In the following general history of the *Astasiæa*, our description will chiefly apply to the two genera *Astasia* and *Euglena*, respecting which we have very copious details in the papers by Mr. Carter, (*A. N. H.* 1856, xviii.).

Of the remaining genera, some comparative observations will be made in passing, and particular researches respecting them added from Perty and other inquirers.

Euglenæ and *Astasiæ* are mostly spindle-shaped (fusiform), and give off from their anterior extremity one or two delicate filaments, and posteriorly a usually short blunt tail. Excluding the doubtful *Eugleneæ*, which, on account of their rigid integument, we think, with Dujardin, should be transferred to another family, the remaining species of the two genera in question are, from their inherent contractility, capable of varying their form to a remarkable extent; *i.e.*, to use a technical word, they are "*metabolic*." This property is, nevertheless, much more restricted than in the *Amœbæ*; for the *Astasiæa* can send off no offshoots or variable processes like those animalcules, but in all their manifold contortions, elongations, and contractions do not completely lose their primitive figure. In general, the recurrence of the changes of figure is quite arbitrary and without regularity. In *Eutreptia viridis* and *Astasia margaritifera*, however, Perty represents an alternate or peristaltic expansion and contraction of the organism, so that first the anterior and then the posterior extremity expands. He adds, besides, that in this *Astasia* the contained clear globules are not transferred backwards and forwards, but only a fluid matter which runs in channels between them.

The *Astasiæa* are covered by a distinct flexible and elastic envelope, which Mr. Carter calls the "pellicle," and states that it resembles the covering of *Amœbæ*, is structureless, and hardens after secretion. Stein also affirms that in *Euglena* it is similar to the enclosing membrane of *Gregarina*, and, like it, a shut sac without mouth or other aperture. On the contrary, the translator of Kölliker's paper on *Actinophrys* (*J. M. S.* i. p. 100, note) denies the existence of a distinct envelope to this genus. Beneath the pellicle, adds Mr. Carter, is a transparent moving substance, with an inherent property of contractility and polymorphism, which proves itself independent of the superposed pellicle when, in the process of encysting, the two become separated: this substance is the "*diaphane*."

Enclosed within these laminæ are the contents, consisting of a protoplasmic matter with suspended particles and certain definite structures, viz. a nucleus and contractile vesicle (XVIII. 46 *a*, *c*). The protoplasm is the same matter Dujardin names the "sarcode," and is occupied with a varying quantity of corpuscles, differing among themselves in size, and imparting the colour peculiar to the species.

"In *Euglena*," writes Mr. Carter (*op. cit.* p. 119), "the sarcode is separated from the diaphane by a layer of pointed sigmoid fibres, arranged parallel to each other, so as to form in *Crumenula texta* (Duj.) a conical cell, which, so soon as the ovules have become developed, and the diaphane and other contents of the sarcode have died off, becomes transparent, although it still retains its conical form until the resiliency of the fibres, now unrestrained by the diaphane and other soft parts, causes dehiscence, and sets the ovules at liberty."

These fibres are therefore the cause of the spiral markings of several *Euglenæ*, as well as of *Phacus* and *Chonemonas*; they are strongly marked in *Euglena spirogyra*. "In another specimen of *Euglena*," says Perty (p. 57), "of fully a sixth of a line in length, and of a grass-green colour, some thirty delicate longitudinal lines were perceptible, which, when the body turned on itself, looked as if spirally disposed. Moreover, on examining *Lepocinclis*-globules when partially dried, the spiral lines appear composed of rows of closely arranged dots"—a phenomenon probably explicable on the supposition that the fibres, as a consequence of evaporation, have been broken up into particles by the act of diffluence.

Mr. Carter distinguishes certain minute colourless granules diffused in the general protoplasm of the interior, which he specially designates "molecules." These, says this observer, are the first to appear in the homogeneous sarcode, but afterwards become intermixed with larger corpuscles—"granules"— and with "ovules;" and by the time the ovules have become fully formed, the sarcode and its molecules have dried off or disappeared. "Moreover, in *Astasia*, digestive globules also appear; but here the food is taken in through a distinct mouth, while in *Euglena* the absence of such vesicles would appear to indicate that its support is of a different kind, if not introduced in a different way."

Ehrenberg noted the existence of a contractile vesicle at the anterior extremity of *Euglena*; the like is also seen in *Astasia*; but in neither instance have its pulsations been directly observed. A nucleus is also present of a discoid shape, and surrounded, according to Mr. Carter, by a transparent capsule, which appears like a narrow pellucid ring around it, owing to its greater size. In *Chlorogonium* and *Amblyophis*, Ehrenberg encountered what he called a seminal gland, *i.e.* a nucleus, and, in the latter genus, mentions the presence of two wand-like bodies in front and three behind it. Thirteen such peculiar structures were also seen by Perty in a large specimen of *Euglena spirogyra*, which he concluded had originated from a peculiar disposition of the internal substance. The same ambiguous structures are doubtless referred to in the following paragraph by Mr. Carter, although, indeed, structural peculiarities are detailed which would render Perty's explanation inadmissible unless qualified in some measure (*A. N. H.* 1856, xviii. p. 241):—"With reference to the single, glairy, capsuled body which exists in the centre of *Phacus* and in the large lip of *Crumenula texta*, also dually in *Euglena geniculata*, Duj. (*Spirogyra*, Ehr.), on each side the nucleus, I can state nothing further than that in the two first it consists of a discoid transparent capsule, which at an early stage appears to be filled with a refractive, oily-looking matter; that it is fixed in a particular position, and remains there apparently unaltered, with the exception of becoming nucleated, until every part of the animalcule has perished, and nothing is left but the spiral-fibre coat, and perhaps a few ovules. In *Euglena geniculata* it is bacilliform, and contains a correspondingly-shaped nucleus; and although I can state nothing respecting its uses, I cannot fail to see that it has an interesting analogy, particularly in the latter instance, with two similar organs which are commonly seen in the *Navicula*, and which in *N. fulva*, *e.g.*, are situated in a variable position between the nucleus and the extremities on either side."

The numerous globules diffused throughout the body, which, in addition to the foregoing, make up the contents of the *Astasiæa*, and according to Ehrenberg are to be considered ova, have, after being denied that nature by Dujardin and others, been again brought to notice under the name of ovules or germ-cells by Perty and Carter. They are, in the words of the latter observer (p. 223), nucleated cells, which, at an early stage, "consist of a transparent capsule lined with a faint yellow film of semi-transparent matter, which subsequently becoming more opaque and yellowish, also becomes more marginated and distinct, and assumes a nucleolar form." . . . . "In the discoid cells of *Astasia* I have seldom been able to distinguish the capsule from the internal contents, on account of their smallness and the incessant motion of the animalcule. In *Euglena*, however, they are very evident; and it is worthy of remark, that each partakes of the form of the

Euglena to which it belongs. Thus, in *E. acus* it is long and cylindrical; in *E. viridis*, oblong and compressed; and in *Crumenula texta* and *Phacus*, circular and compressed.

There is yet another set of structures pointed out by Mr. Carter, developed from the nucleus, to which he assigns the nature of spermatozoids, or male reproductive particles. "In *Astasia*," he writes (p. 227), "irregular botryoidal masses, dividing up into spherical cells, colourless and translucent, or of a faint opaque yellow tint, present themselves so frequently (and generally inversely developed with the ovules, as in the *Rhizopoda*), that I cannot help thinking that they are also developments from the nucleus; but, from not having seen them present that evident granular aspect which characterizes this development in the *Rhizopoda*, I have not been able to determine satisfactorily whether they are parts of the latter, or that kind of division of the sarcode into green spherical cells which sometimes takes place in *Euglena*.

"In *Euglena*, also, I have described a development of the nucleus partly under the idea that it might be a parasitic Rhizopodous development; but now it appears to me a simple enlargement, granulation, and segmental development of this body into polymorphic, reptant, mucous cells filled with spermatozoid granules, as in *Rhizopods*..... I have never been able to see the nucleus and its capsule in their original form when the spermatozoid mass has been present, though I have occasionally in *Amœba*, and almost always in *Euglypha*, seen the empty globular capsule in connexion with the latter."

The contents of *Astasiæa*, even of the same individual, are subject to great variations in colour, distribution, and other characters, induced by age, the action of the reproductive processes, and the influence of external conditions. Thus, Perty tells us (p. 57) *Phacus pleuronectes* is at times filled with a homogeneous green mass, at others has a large, round, central spot (vacuole or nucleus?), at others a large, clear space in the middle, having a central dark nucleus; and at others, again, the contained endochrome forms three or four segments, each exhibiting many dark green nuclei. In *Euglena viridis* and *E. Acus* the contents become resolved into a formless mass, or into a heap of nearly equal-sized germ-cells, and frequently the colour is changed from green to red, or the whole organism is rendered hyaline by the escape of the colouring matter.

The coloured speck in *Euglena*, *Amblyophis*, and other *Astasiæa*, reckoned as an eye by Ehrenberg, has in fact no pretensions to that character. We have pointed out that similar specks occur in *Volvox* and other generally recognized plants, in all probability precisely similar to and structurally the same as those of *Astasiæa*. Sometimes in *Euglena* the red is diffused over the entire body, as Cohn represents to occur in *Sphæroplea annulina* (*A.N.H.* 1856, xviii. p. 83), in small globules, which have the physical and chemical relations of oil. In other instances, and occasionally in very young forms, the red stigma is altogether absent. In *Phacus pleuronectes*, Perty states, one speck is placed close behind another with an intermediate band uniting them. Often in *Euglenæ*, instead of one stigma, two or more red granules occur, whilst in *Euglena deses* the pigment-mass is quite irregular. In *Crumenula* the red spot is comparatively very large, and rests in the form of a small obtuse cone upon the contractile vesicle.

"The eye-speck of *Euglena viridis*," says Perty (p. 117), "is round or oval, and exhibits an elliptic or spherical vesicle, within which the colouring matter is contained, surrounded by a more or less complete brownish-black ring: at a subsequent period the colouring matter is diffused in a most irregular manner beyond the ring." In *Amblyophis viridis* the red pigment may either entirely or only partially fill the dark areola. Perty very sensibly remarks, "All these red stigmata are deficient of all the requisites of an eye—they have no refracting medium; and the presence of an eye is inconceivable among beings which have neither nervous centres nor communicating nerves. They are probably nothing more than drops of red-oil, like those which are produced among the chlorophyll in unicellular Algæ" (p. 118). Another fact, bearing on the character of a red pigment-speck in *Euglenæ*, is the change of colour these beings at times undergo from green to red, just as *Chlamydococcus* and various unicellular Algæ do when they enter on the "resting" stage.

Reproduction of Astasiæa.—In Ehrenberg's opinion, the members of this family are reproduced both by self-division and by ova: he speaks of having witnessed the former process in the genus *Euglena*, but only as a rare occurrence. In other genera he failed to discover it. When fission takes place it does so in the usual manner, longitudinally, and produces two equal and similar organisms; rarely, the new beings are of unequal size. Moreover, in the encysted condition, which was mistaken by Ehrenberg for the death of the *Euglena*, or confounded with other structures, fission is a constant phenomenon.

When the motile *Euglena* becomes "still," or enters into a state of rest, it contracts itself into a ball, and, while retaining its red stigma, loses its filament. A gelatinous layer is thrown out around it, which gradually hardens into a rigid colourless cyst: this at first lies close upon the mass of the *Euglena*, but ultimately is removed from it all round by an interval; and when quite mature, it frequently acquires a brownish colour and opacity. In the encysted condition, *Euglena* closely resembles the "still" cells of *Protococcus*; hence the term "*Protococcoid*," to express this condition. When *Euglenæ* have undergone this transformation, they cohere together by a mucilaginous excretion, so as to form expansions or films resembling in appearance those produced by many *Palmelleæ*.

This close resemblance subsisting between encysted *Euglenæ* and the resting-spores of numerous Algæ, *e. g.* of *Œdogonium*, explains many of the wonderful transformations recounted, such as the germinating of encysted *Euglena*-cells into branching filiform Algæ. Again, the filmy masses produced by *Euglenæ* have been described as independent genera and species of Algæ,—as, for instance, those formed by *E. viridis*, as *Microcystis olivacea*, and those by *E. sanguinea*, as *Microcystis Noltii*.

That the contained green *Euglena* is not dead within its case, is proved by its sometimes being seen to revolve within it, and also by the circumstance that, in the early period of encysting, on rupturing the cyst, the contained being escapes and resumes the appearance and movements of its free brethren. It would seem, indeed, that *Euglenæ* are in the habit of temporarily encysting themselves as a means of protection against injurious external causes, such as evaporation, and that, when a normal condition is restored, they throw off their protecting envelope and reassume their active contractile character and movements. The empty cases are often to be met with floating on the surface of water, united with others and with encysted *Euglenæ* in a common membranous mass. The vitality of the enclosed being is further displayed by the process of fission, which advances in the power of two until very small segments are produced, which soon develope severally a red speck and filament, and, on the dissolution or rupture of the common cell-wall of the parent, escape as small free-moving corpuscles rather resembling Monads than *Euglenæ* by their minuteness.

The encysting act may transpire in very small as well as in large *Euglenæ*, and the subsequent fission may be arrested at any point, so that either a few sections which, in the phraseology of botanists, may be called macrogonidia, or otherwise very numerous small ones, or microgonidia, may be developed.

As the simply encysted *Euglenæ* have been represented as independent genera of plants, so the same thing has occurred when their contents have been seen in the process of self-division; thus, for instance, Perty thinks it probable that *Protococcus turgidus* and *P. chalybeus* (Kütz) are no other than two such transitional conditions.

Another circumstance attending encysted *Euglenæ*, is the forming an attachment to other bodies by a sort of pedicle, which extrudes from what has been the anterior extremity of the being. When viewing large collections of *Euglenæ*, specimens may occur of two or several united together by the head or tail, sometimes with the tail of one to the head of another. Examples of two partially united have been explained by supposing the act of fission of a parent-animal to be nearly accomplished; but other observers have seen in such united beings an instance of conjugation, *i. e.* of an act, to some degree, of impregnation. The union, however, of several by the tail, sometimes seen, is an argument against this supposition, and is rather suggestive that such combinations are the remnants of primitive adhesions between gonidia within the parent-cell or between germs before a pellicle has formed around them, or, again, that a mucoid matter thrown out from the surface, as happens in many *Phytozoa*, may constitute the band of union, when incomplete fission or persistent primitive adhesions cannot be considered its origin. There is certainly no *à priori* argument against the occurrence of conjugation in this family, and some naturalists would, from analogy with related beings, look for it; but at present it has not, we think, been proved.

Ovules or germs.—That *Euglenæ* reproduce by internal germs is an opinion now advocated by several naturalists. To our minds this mode of propagation is really homologous with the formation of gonidia in admitted plants. Kölliker writes (*J. M. S.* i. p. 34)—"Multiplication by means of germs generated in the interior indubitably occurs in certain Infusoria: in *Euglena* four to six embryos are seen in one individual, entirely filling it, which at length, furnished with their red speck and filament, break through their parent, leaving it as an empty case."

Mr. Carter (*op. cit.*) has entered very largely into an account of the ovules of Infusoria and of their development. "In *Euglena viridis*," he writes, "the ovules are of an oblong shape: they are found, like those of *Spongilla*, scattered over the sides of the vessel, and evidently have in like manner the power of locomotion in addition to that of turning upon their long axis when otherwise stationary. . . . The pellucid central area in them corresponds with the oblong shape of the capsule; but beyond this and the central granule I have not been able to follow their development out of the parent, though, from the number of young *E. viridis* present, it may be reasonably inferred that they came from the ovules. The young *Euglenæ*, however, being so rapid in their movements when once the cilium is formed, it can hardly be expected that, except under a state of incarceration, their development can be followed so satisfactorily as that of the slow-moving *Rhizopod*. Instances do occur, however, where the ovules gain the cilium within the cell, and there bound about when fully developed like the zoospores of Algæ within their spore-capsules. In this way I have seen them moving rapidly within the effete transparent capsuled body of *E. viridis* and in *Crumenula texta*, where the spiral-fibre layer is so strongly developed as to retain the form of the *Euglena* for a long time after all the soft parts have perished. On these occasions the embryos are perfectly colourless, with the exception of a central point which reflects a red tint; and on one occasion, while watching a litter in rapid motion within the encysted body of *E. viridis*, the capsule gave way, and they came out one after another just as zoospores escape from the spore-capsule; but, from their incessant and vigorous movement, I was unable to follow them long enough to make out anything more about them."

This same observer, moreover, refers to a rhizopodous development of the nucleus of *Euglena*, whereby the form of an "actinophorous *Rhizopod*" is assumed, from which, in his opinion, young *Euglenæ* are probably developed.

Perty, again, records some original observations on the development of *Euglenæ* from ovules or, as he terms them, germs (Keime). At p. 79 he states that, among numerous very minute resting germs, intermingled with larger individuals, some were seen to acquire the faculty of motion, to stretch themselves out, and to assume the form of *Cercomonas*. Between such and completely-formed *Euglenæ* every intermediate size occurred. The motionless spheroidal germs set free by the dissolution of the parent-cell soon develope a tapering extremity, terminated by a locomotive filament, at the base of which is a hyaline space, and in and near to this a dark speck which subsequently changes to red. The differentiation of the homogeneous contents of the granules, out of which the germs are to be developed, takes place at a very early period, but not in the same way or time in all specimens; neither do all the young of a brood attain the same dimensions and figure; indeed but few attain a considerable size, and many acquire an abnormal figure. For example, Perty regards *Amblyophis viridis* as only an accidental variety of *Euglena*, of large size and truncate at one end; for he has remarked numerous small individuals, derived from a *Euglena*, also with a truncated extremity. Further, he reports the multiplied varieties in form, in colour, and in arrangement of contents, &c., which occur in collections of the same species of *Euglena*, and adds that the great differences exhibited by *E. viridis*, when in a dying condition, are most varied and inexplicable. In illustration of this opinion, he remarks that the utmost variety of form occurs; or all the vesicles and granules change to a red colour or become transparent; or the vesicles vanish and the green mass contracts itself into a small ball, or otherwise disappears, leaving only an empty shell. In the last-named state the stigma often retains a black colour. The empty envelopes frequently accumulate so as to form masses resembling a vegetable cellular tissue, and in one instance approached, by mutual pressure, a regular hexagonal figure. Some such accidental groupings of withered *Euglena*-cells have been, as Perty believes, described under the name of *Palmella botryoides* by Kützing; and *Cercomonas viridis*, and also probably *Bodo viridis*, are merely phases of development of *Euglena viridis*.

There is a distinct concordance between Carter's and Perty's account of the development of the contents of *Euglenæ* into minute germinal bodies, or, as we may legitimately call them, microgonidia; and, on the other hand, the formation of two- and four-fission products (in other words, the formation of macrogonidia from these beings in their still-condition) has been a matter of direct observation. Consequently the developmental history of *Euglena* is so far complete; and it only remains for naturalists to witness the actual relation, the contact and incorporation of the micro- with the macrogonidia, to bring this genus within the same pale as *Volvox*, in reference to its sexuality.

Mr. Carter has reverted to his notes on the ovules or germs of *Euglena*, in his just-published paper on *Eudorina* (*A. N. H.* 1858, ii. p. 245), in the following remarks:—"There is no doubt that *E. viridis* becomes distended with the cells which I have heretofore described, and thought to be ovules or embryonic cells, and that during this time the chlorophyll passes into red grains, and subsequently disappears, while the organism is secreting a capsule around itself, and its original cell-wall passes into a tough spherical ovisac, so to speak. But what becomes of this, if it be the result of impregnation, or what the process of impregnation is like, or when it takes place, is for future discovery to determine."

Chlorogonium euchlorum (Pl. XX. 15–21) was the subject of an interesting observation by Weisse (Wiegmann's *Archiv*, 1848), who thought he had demonstrated in this species propagation by ova or germs, and, in fact, elucidated in it the development of microgonidia, by repeated acts of self-fission of the contents, just as in the spores of Algæ. For instance, he described the contained green matter of the fusiform being first to contract in some measure upon itself (XX. 16), then to exhibit a constriction followed by a line of division into two portions, which, by subsequent redivisions, resolved the whole into a nodular mass resembling a bunch of grapes (XX. 17–18). This grapebunch-like mass possessed a certain mobility within the enclosing integument; and as the process of development proceeded further, its several particles or segments displayed a movement among themselves, which increased in extent and vigour until the external envelope gave way before it, and permitted their escape in the form of so many distinct particles or beings (gonidia) endowed with ciliary filaments, whereby they kept up an active movement in the surrounding water (XX. 21). The young forms produced exhibited active movements within the parent-cell, and at one stage prior to their discharge, when connected together in heaps, resembled *Uvella Bodo*. On the rupture of the cyst they escaped freely into the water with the figure of *Chlorogonium*.

Schneider has also some remarks on this genus (*A. N. H.* xiv. p. 326). He could discover no decided red speck, although as many as twelve reddish spots were distributed over the surface of the green mass; a contractile vesicle, moreover, eluded his search. Of the mode of propagation he reports that "division takes place in the interior of the investing membrane, in exactly the same manner as in *Polytoma*. The number of individuals produced is never less than four, but often as many as thirty-two; in the latter case they are very small, but always resemble the parent in other respects. A spherical state of rest also occurs. It appears that, when the requisite conditions are present, the young proceeding from the division of the parent pass into this state immediately after they are set free,—their soft investing membrane probably rendering them fitter for this purpose. The contractions which then take place are probably the same that were observed by Ehrenberg. In other respects I have found the form unchangeable; and *Chlorogonium* must consequently be separated from the *Astasiæa*, amongst which it has hitherto been arranged. On the addition of iodine, only a few blue granules are to be seen in the fusiform individuals; the green spheres, on the contrary, which are completely filled with green granules, acquire a deep blue colour with this reagent: if the colouring-matter be destroyed by means of concentrated sulphuric acid, the granules are dissolved, and on the addition of iodine, a beautiful blue colour is produced. By long keeping, the green of the cyst passes to red. The cysts are not to be roused from their torpid condition by the production of fermentation. I have, however, observed their revivification under other circumstances; but my materials are insufficient to enable me to describe the mode of reproduction of the investing membrane and filaments, which would certainly be interesting. The conditions required for the existence of *Chlorogonium* are apparently quite different from those of *Polytoma*: the former did not multiply abundantly in infusions until the latter had passed to the state of repose." This view of the affinity of *Chlorogonium* accords with that which Weisse indicates in the statement that this genus and *Glenomorum tingens* (species of Ehrenberg's family *Monadina*) are but two phases of the same being.

Weisse has appended some remarks to the preceding account by Schneider *Müll. Archiv*, 1856, p. 160). He says that he witnessed the revivification of encysted *Chlorogonia* (a phænomenon unnoticed by Schneider) on placing some cysts, collected the preceding year, in water. The reddish and previously spherical cysts were seen to gradually lose their regular outline by the elongation of one end, and thereby to acquire an ovate form. After a short time the narrower end of the cyst ruptured, and a very thin-walled vesicle protruded through the rent: whilst this took place, a movement of the contents of the cyst became evident; and after a while several constrictions appeared, which extended deeper until they divided the whole into four portions. For a time the protruding sac elongated itself more and more, but ultimately, owing to the pressure within it of the moving particles, gave way and allowed their exit. The escaped sections were, as a rule, of pretty uniform sizes, but had not the remotest resemblance to the mature *Chlorogonium*, and indeed might have readily been assigned to another group of beings. Their figure was elongated, irregular, and often triangular, on first escaping from the cyst; they were also flexible in every direction, and of a dusky brown colour. After dispersion, on reaching the margin of the drop of water, they resumed a globular shape, changed to a rusty red colour, and after a few hours assumed the appearance of clear-green spindle or bodo-shaped organisms. Between their evolution from the cysts and their development into the form of *Chlorogonium*, two hours, less or more, intervened. This division into four segments, representing four new beings of *Chlorogonium* progressively evolved, apparently without actual metamorphosis, may be rightly esteemed an act of reproduction by macrogonidia, whilst the breaking up of the organism into a multitude of zoospores, as previously described by Weisse, is a process of reproduction by microgonidia.

Nature of Astasiæa.—It is with certain members of this family that Thuret pointed out (*Ann. Sc. Nat.* 1850, xiv.) the close resemblance to the zoospores of Algæ, amounting, as far as outward appearances indicate, to actual identity.

"This affinity," he says, "is exhibited in the colour, form, in the number and character of the ciliary filaments, in the contents, not excepting the coloured eye-speck, in the mode of self-fission, and also in the power of locomotion. What is still more, both zoospores and *Astasiæa* tend to the light, disengage a gas, most probably oxygen, and emit a peculiar spermatic odour. However, by continued watching the zoospores are seen to affix themselves to some body, surrender their seeming animal life, and proceed to germinate, developing a tissue similar to that of the plant which gave them birth. On the other hand, the true *Astasiæa*, if they attach themselves, it is but for a time, and no appearance of germination ensues. The closest similarity exists in the case of the *Chlamydomonas pulvisculus* (*Diselmis viridis*, Duj.), and in a less degree in the *Euglenæ*. . . . In the form of the body, in that of the flabelliform cilia, and in the disposition of those cilia, as also in the contents of the body, the resemblance is complete. The movements of *Diselmis* are like those of zoospores: and, like them, they tend to the light. In one distinct species, or rather, in a particular state of the same species, a very clear red spot is discernible, and a central globule, very like in appearance to the amylaceous granules so frequent in the cells of green Algæ. These Infusoria appear to act on the atmospheric air like Algæ and the green parts of other plants, disengaging a gas (oxygen ?) under the influence of light. They exhale an evident spermatic odour. Their reproduction occurs by spontaneous division, 2-4 young ones being formed within the common integument. I have observed the same mode of reproduction in the *Euglenæ*, which act on the air and turn to the light like *Diselmis*, but have an extremely contractile body changing its figure every moment, which will not admit of their being confounded with zoospores, and leaves no doubt of their animality. This binary or quaternary division is met with also in the various species of *Tetrasporæ*, which, though arranged with the Algæ, appear to me of very doubtful vegetable nature. In *Tetraspora gelatinosa* I have recognized green globules, disposed in fours, and each furnished with two cilia of extreme length, which are lost in the gelatinous mucus of which the frond of this supposed plant is constituted. All these productions, as well as *Gonium, Pandorina, Volvox, Protococcus nivalis*, &c., present, in my opinion, characters of animality too decided and too permanent for it to be possible to refer them to the vegetable kingdom; and I think it would prove more convenient to unite them, with all the other Infusoria (*Polygastrica*) coloured green, in one and the same group, which might be called *Chlorozoideæ*. We have before noticed the sweeping statement of M. Agassiz, that all the mouthless Infusoria are nothing but various forms and phases of development of Algæ."

Although many naturalists stoutly claim the *Astasiæa*, and the genus *Euglena* especially, as plants, yet others, and among them some of the most able, particularly in Germany, still pronounce them animals. But, as we have before noticed, there are undoubted *Euglena*-forms which are actually phases of existence of known plants, and which, if watched, may be followed in their development until by germination they assume all the special features of those plants; and, on the other hand, there are *Euglenæ* which at no period of their existence can be seen to germinate, although they may exhibit a plant-like condition when encysted and motionless, like *Protococcus* resting-cells.

As an example of the former set of transitional beings, we may appeal to the observations of Itzigsohn already recorded (p. 125), showing that, in the development of *Oscillatoriæ*, minute *Chlamydomonads* are transformed into *Euglenæ*, that these in their turn generate microgonidia, which, after some intermediate transformations, eventually produce the '*Leptothrix*,' and lastly the perfect *Oscillatoria*. Another illustration might be adduced from Cohn's essay on *Protococcus pluvialis*, in which he points out both an *Astasia*- and a *Euglena*-like phase of that unicellular plant. Let it, however, be noted that whilst Cohn records a *Euglena*-phase in *Protococcus*, he nevertheless admits the existence of animal *Euglenæ*, distinguished by their extraordinary contractility (*Entw.* p. 208). Withal, this distinguished observer's discovery of the mutual sexual relation of micro- and of macrogonidia constitutes (supposing these reproductive products, as seems to be actually the case, to be generated in *Euglenæ*) an additional argument for their vegetable nature, by bringing them within the same category of organized beings as *Volvox* and *Pandorina*.

If Mr. Carter be correct in his account of *Astasia*, this genus can no longer remain in the category of doubtful organisms, but must forthwith be transferred to the animal kingdom; for he asserts the existence of a mouth with a complicated buccal apparatus for biting off and taking in food, of a strong prehensile organ, and stomach-sacs. Besides, he speaks of its near affinity with *Amœba*, and refers it to the *Rhizopoda*. In *Euglena*, on the contrary, no mouth- or stomach-vesicles are discoverable, and the filament is comparatively imperfectly developed; hence Mr. Carter allies this genus rather with the zoospores or gonidia of Algæ, and assumes that it must, like other mouthless organisms, derive its nutrition through endosmosis. Cohn, on the other hand, although cognizant of many plant-like features in *Euglena*, cannot acquiesce in detaching it from animalcules, because of its great contractility and of the fact that there are undoubted animals, such as *Opalina*, *Rhizopoda*, *Gregarina*, *Trematoda*, &c., which want the special animal characteristic of a mouth.

Mr. Carter would, it seems, recognize both *Euglena* and *Astasia* as close allies with *Amœba*,—an affinity remarked by Ehrenberg, who placed the family *Astasiæa* between *Closterina* and *Amœbæa*, treating the variability of the form of the body as a leading characteristic. Indeed, the first-named observer alludes to an actual transition of *Astasiæ* into *Amœbæ*, in the following paragraph (*A. N. H.* xvii. 1856, p. 115):—"Young *Astasiæ* are developed within the cells of *Spirogyra* to a great extent; and although they at first have almost as much polymorphism as an *Amœba*, still they retain their cilium, and after a while assume the form and movements peculiar to *Astasia*. I might here mention that on one occasion I saw a *large Amœba* with a long cilium at one time assuming the form of *Astasia*, and at another that of *Amœba*, which thus gives us the link between these two Infusoria. The cilium, however, had not the power of the filament of *Astasia*, though it occasionally became terminal." At a previous page, a rhizopodous development of the contents of *Euglenæ* into granuliferous *Amœbæ* of a pinkish colour has been adduced as a fact noticed by the same observer.

We need not stay to examine the vital endowments and habitats of the *Astasiæ*; for, except the facts occurring in the preceding history of the family, and in the general account of Phytozoa, there is nothing important to adduce.

SECT. III.—OF THE PROTOZOA.

(Plates XXI.–XXXI.)

THE term *Protozoa*, borrowed from two Greek words, *protos*, first or primitive, and *zoon*, an animal, has of late been very generally adopted to signify the simplest forms of animal life. Upon a review of these rudimentary animals, it is at once perceived that they differ among themselves in organization—that whilst some are amorphous and almost homogeneous, others exhibit a degree of differentiation of parts, and the first vestiges of internal organs to carry on the processes of life; again, it is seen that some have a distinct orifice for the admission of food, or a mouth, which in others is absent, and, lastly, that some with a definite figure are moved by vibratile cilia, whilst others slowly progress by the alternate protrusion and retraction of ever-changing and changeable processes derived from the general mass of their body.

From a consideration of these structural differences, one division of the *Protozoa* is suggested into those moved by cilia, and those moved by variable processes or '*pseudopodes*'; and a second, into those furnished with a mouth, and those which are mouthless. We have accordingly constituted two primary divisions, viz., 1. *Ciliata*, Protozoa moved by cilia; and 2. *Rhizopoda*, moved by variable processes. The *Rhizopoda* (XXI.) are all mouthless, or 'astomatous,' whilst the *Ciliata* (XXIV.–XXX.) have a mouth, and are styled by Siebold '*Stomatoda*,' with the exception of a small family, the *Opalinæa* (XXII. 46, 47), and perhaps also of that of the *Peridiniæa* (XXXI. 16–23).

However, besides the beings usually included among the *Ciliata* and *Rhizopoda*, there are several subordinate *Protozoic* groups, some of which either stand as it were midway between them, or represent a development of the amorphous and mouthless *Rhizopoda* in a different direction; such are the *Gregarinida* (XXII. 28–36), with the associated *Psorospermia* (XXII. 37–41), the *Spongiada*, *Thalassicollida*, and *Polycystina*, all which must rightly also be numbered with the *Protozoa*.

Of the CILIATA themselves, there is a further and higher development of their type in the subordinate groups of *Ichthydina* (XXII. 46–47) and *Noctilucida* (XXXI.), and, on the other hand, a degradation of it, as already noted, in the case of the *Opalinæa* and *Peridiniæa*. Here we would remark that the term '*Infusoria*' has been employed by several writers, in lieu of that of *Ciliata*, which we adopt; still it is, to our mind, both less appropriate, and also open to objection, not only on account of its meaning being quite indefinite, but also by its having everywhere acquired a very much wider signification, in consequence of which it will always be open to misconception when applied to a comparatively very small class instead of, as heretofore, to a very various and wide collection of microscopic organisms. Another word invented is '*Stomatoda*,' which is precisely equivalent in the extent of its signification with the term *Ciliata*, the mouthless families only being excluded.

Excepting their subordinate groups, the organisms comprehended among the *Ciliata* and *Rhizopoda* formed, in conjunction with the *Desmidieæ*, *Diatomeæ*, and the families we have brought together under the appellation *Phytozoa*, the great class *Polygastrica* in the system of Ehrenberg. Little reflection is necessary to convince ourselves of the very heterogeneous nature of the collection of living objects assembled in that class; and even Ehrenberg himself would never have suggested such a grouping, had he not imbibed the hypothesis of a pervading uniformity of organization possessed by the simplest animated beings in common with animals considerably advanced in the scale, and under its influence, aided by his imagination, found in all these various organisms, a polygastric structure, viz. an apparatus of numerous stomach-sacs, communicating directly or indirectly with the mouth. Notwithstanding the many prominent errors in Ehrenberg's classification, he rightly recognized in framing it the value of the external means of locomotion, and distinguished a group of *Polygastrica* under the name of *Pseudopoda*.

Siebold, who proposed the term *Protozoa*, limited it to two classes, distinguished as the 'Infusoria' and the 'Rhizopoda', omitting the supplementary groups above mentioned. The Infusoria he divided into two orders, the '*Astoma*' and '*Stomatoda*,' the latter of which, together with two of the three families of *Astoma*, is equivalent to our class *Ciliata*, its remaining family *Astasiæa* being a member of our group of *Phytozoa*.

The *Protozoa*, as understood by us, may be thus exhibited at one view.

CILIATA.

a. Astoma { Opalinæa, Peridiniæa (?) }
b. Stomatoda

RHIZOPODA.

a. Amœbæa
b. Monothalamia or Monosomatia
c. Polythalamia, Polysomatia, or Foraminifera.

Gregarinida
Psorospermia

Ichthydina, Noctilucida } .....Supplementary groups...... { Polycystina, Thalassicollida, Spongiada

In treating of these several classes and groups we shall commence with the *Rhizopoda*, omitting, however, lest our subject-matter be too much extended, the *Polycystina*, *Thalassicollida*, and *Spongiada*; we shall next proceed with a brief description of the *Gregarinida*, and its subordinate family *Psorospermia*, and then after considering the *Opalinæa* and *Peridiniæa* as intermediate groups, proceed to detail the history of the perfect *Ciliata*—the *Stomatoda*,—finishing our account with the *Ichthydina* and *Noctilucida* as the highest developments of Protozoic life.

As a result of our inquiry, we shall see, on the one hand, in the true Ciliata, simple animal organized matter, with a very slight amount of differentiation, attain its acme of development in the *Vorticellina*, and in these animalcules exhibit a superiority in organization above the lowest links of groups relatively higher in the chain of animal life; and, on the other hand, in the Rhizopoda, of still simpler organization, the same organic living material developed in a totally different direction to a maximum in the most beautiful and complex-shelled *Foraminifera*, which in outward form, although in no real homology, emulate the highest class of Invertebrata, viz. the Cephalopoda.

Another lesson may also be derived from the objects of our present study, viz. the fact of the marvellous variations which can be made out of one or, it may be, two elementary structures. Thus the simple contractile substance which can live independently in the *Amœba* condition (XXI. 1–4; XXII. 1–23) encases itself in a one-chambered shell in the *Monothalamia* (XXI. 6–19), and into a many-chambered one in the *Polythalamia* (XXI. 20–36), and again lives partly within and partly without the curious silicious skeleton of *Poly-*

cystina, and in singular relation with a spicula skeleton in *Spongiada* and *Thalassicollida*.

So, if we look to the Ciliata, we find that the hardening of the superficial lamina of their substance into a sort of integument gives rise to numerous modifications in external form and functions, according to the degree of induration, and the processes sent out. The flexible-skinned *Colpodea* (XXIX. 25-50) depend for their movements upon their garniture of vibratile cilia, and are merely swimmers, whilst the hard-coated *Euplota* (XXV. 350-353) produce short moveable processes which act as legs, upon which they can rapidly creep. Lastly, the selfsame primitive contractile substance is formed into a stem in the *Vorticella*, which supports the animalcule at its apex, and exhibits helicoid contractions; astonishing both by their rapidity and completeness.

SUBSECTION I.—RHIZOPODA.

(Plates XXI. XXII.)

The true *Rhizopoda* constitute a large class of microscopic animated beings of the most simple character. They may be defined as non-ciliated Protozoa moving by variable expansions. Their organic animal substance presents no distinction of tissues or of organs, but is homogeneous, contractile, and translucent, resembling a tenacious mucus or soft tremulous jelly, and is perpetually changing its form by expanding itself at one or several points into processes of ever-varying dimensions, arrangement, and number, and called in consequence "variable processes." Inasmuch, moreover, as these shifting offshoots are their only means of locomotion, they have frequently been called "feet," and, as they are also characteristic of the class, have given origin to the terms "*Pseudopoda*" (with false feet) and "*Rhizopoda*" (root-like feet) to designate it. Again, the living mass is, in numerous instances, capable of enclosing itself by a shell of various figure, consistence, and complexity; and such variations serve to separate the Rhizopoda into families and genera.

In the simplest shell-less beings (XXI. 3, 4), vitality is exhibited by the slow protrusion and retraction of the variable processes, by the change of form, their onward movement, and the introduction of nutritive substances, and by the gradual changes of the introduced matters indicating a digestive act. They therefore manifest vital contractility, a power of locomotion, a degree of sensibility, and a digestive process.

Repeated observation likewise reveals the fact of progressive growth, and the faculty of reproduction. The testaceous forms exhibit their vitality after the same manner, and surpass the naked Rhizopoda only in the marvellous power of secretion displayed in the production of their shells (XXI. 6-36).

Although in organization the Rhizopoda stand even below the ciliated Protozoa, yet an animal nature must be allowed them; indeed the simplest forms are the rudest specimens of animal existence. Under the term *Rhizopoda* are comprised three well-marked families, viz. the *Amœbina* or *Amœbæa*, which are without, and the *Monothalamia* and the *Foraminifera*, with shells. The *Monothalamia* have one large opening to their monolocular (one-celled) shells (XXI. 6-17)—hence the name,—whilst the *Foraminifera* owe their designation to the existence of numberless small orifices, generally distributed over a multilocular (many-celled or chambered) testa (XXI. 20-36).

We have frequently, in the following pages, used the term *Arcellina* as synonymous with *Monothalamia*; for although the family known to Ehrenberg under that name comprehended only a portion of the genera that Schultze arranges in his group of single-chambered or monolocular shells, yet its meaning may be equally extended.

It would probably have been correct to have placed the *Acinetina* (XXIII.) among the Rhizopoda, as another family closely allied to the *Amœbina*; but the detail of their peculiarities would have too much embarrassed the general description of structure which we have endeavoured to give of all the usually acknowledged or true Rhizopoda; we have therefore preferred to describe them as a subclass in the following chapter.

The examination of the Rhizopoda requires to be conducted with great care and skill,—a requirement sufficiently illustrated by reference to the erroneous notions and descriptions of the older observers. They must be viewed in all positions under different degrees and modes of illumination, by reflected as well as by transmitted light, and, especially in the case of the testaceous varieties, after submitting them to pressure and to the action of various chemical agents, or, when sufficiently large, after making sections of them in different directions.

The organic living mass of all Rhizopoda is alike, and corresponds with the "Sarcode" of *ciliated Protozoa* and with the amorphous contractile substance of *Hydra* and of other low organisms. It appears in the present class a contractile, highly elastic, colourless, almost fluid mucus, hyaline or diaphanous, homogeneous, and in refracting power differing little from water. No distinction into an enclosing firmer membrane or integument and contents is discoverable; and cilia are never found. These characters exist in entirety only in very young animals; for at a very early period molecules, granules, and globules or vesicles, and various foreign particles, make their appearance, diminish the transparency, and often impart colour.

A new species of *Amœba*, figured by Schultze, the *A. globularis*, is represented as having a thin, transparent, colourless lamina of contractile substance, from which the processes are given off, and which surrounds a globular, coloured, and granular chief or nuclear mass (XXI. 1, 2). A similar distribution of the substance of an *Amœba* into a hyaline colourless cortical, and a granular coloured medullary portion, is represented by the same author in another species; and it is moreover a structure homologous with that in the allied genus *Actinophrys* (XXIII. 28, 29). As to the assigned character, of the animal sarcode being destitute of a distinct investing membrane or integument, the shell produced by the testaceous forms might be considered equivalent to one; and if some observations hereafter alluded to be correct, a resistant integument among the Rhizopoda must be admitted as an established fact.

It is possible that in some instances the organic substance has a colour of its own; for instance, Ehrenberg describes *Amœba princeps* as having a yellow colour. However, in general the occurrence of colour is consequent on that of granules, and on the introduction of food; and observation proves that the depth of colour augments with age, and is otherwise in direct relation with the abundance of food. The colour is usually pretty uniformly diffused. Schultze shows this, and also its relation with the thickly-distributed minute granules, in many *Miliolidæ*, *Rotalidæ*, and *Gromiæ*. In larger species (he adds), such as *Polystomella strigilata* and *Gromia oviformis* (XXI. 16), the colour occurs in scattered and much larger particles or vesicles; yet under what form soever found, it is, in the case of the many-celled or chambered *Foraminifera*, deepest in the oldest cells, and progressively fades on approaching those most recently formed, the last being commonly quite colourless (XXI. 28, 33, 36). Experiment also showed that, by depriving the animals of food which could convey colour, other chambers than the last lost their tint, and, *vice versâ*, that by feeding them abundantly with such food, even the animal substance of the ultimate cell acquired colour. Irregular accumulations of colouring particles in the ultimate chamber are of rare occurrence. Ehrenberg has figured such in *Nonionina germanica*.

The colourless, or almost colourless Rhizopods, principally *Amœbæ*, are, owing to their transparency, visible with difficulty, and require nice adjustment of the microscope and of the light to demonstrate their vitality and movements.

Concerning the chemical relations of the organic substance, it is stained yellow or yellowish-brown by solution of iodine, like other proteine matters, and, according to Schultze, is unaltered by diluted acetic acid, is slightly hardened by a dilute solution of the alkalies, and more so by one of the carbonates. Moreover, its resistance to chemical action would seem to differ in different species; for the *Gromia Dujardinii* was the least affected of several animals experimented on.

"The colouring-material," to quote the same writer, "assumes by the action of sulphuric and of hydrochloric acids an intense verdigris green, and by that of nitric acid, first a green and then a yellow tint. Concentrated sulphuric acid destroys the coloured substance, but when combined with sugar, renders it green. By concentrated solutions of potash and soda, the coloured granules are dissipated without change; and in ether and alcohol they are readily and completely dissolved. In these reactions the colouring-matter agrees with *Diatomeæ*, from which, no doubt, it is derived in the form of food."

No definite figure can be said to belong to the animal portion of the Rhizopoda, owing to its capability of throwing out processes in every direction, of various dimensions and in different numbers, changing them almost every moment. Auerbach, however, asserts of the *Amœbæ* that they have normally a spherical figure. Dr. Bailey has pointed out the influence of pressure from within, due to the various articles swallowed, in modifying the figure. The *Amœbæ*, being untrammelled by a shell, exhibit the Protean changes of form in the highest degree, whilst the completely enclosed *Foraminifera* present them in the lowest. In the latter the organic mass must follow the windings of the cavity of the shell (XXI. 24), and can escape only from the foramina (holes) as thread-like filaments, in the form, extension, and subdivisions of which great latitude prevails. We have said that the sarcode of *Polythalamia* follows the windings or adapts itself to the figure of each segment of the shell, and has actually no figure of its own. However, when separated from its calcareous investment by means of an acid, it retains the outline originally imposed on it. Thus (XXI. 24) Schultze exhibits the sarcode substance of a *Miliola* so separated, which shows a constriction at each half turn of the spiral and the delicate membrane which invests it or lines the shell. So, again, Dr. Carpenter, in his description of *Orbitolites*, states that the soft sarcode body is made up of a number of segments equal and similar to each other, and arranged in concentric zones around a central nucleus. Among the *Amœbæ* the variable processes may either be protruded at one time from every portion of the little mucous mass, so that, as Ehrenberg remarks of the *Amœba radiosa*, it may, when fully outspread, be likened to a miniature porcupine; or, otherwise, they may be produced chiefly or entirely from one side; or, as when the animal is moving, they are thrown forward in the direction it is progressing, and retracted on the opposite side. Among many *Monothalamia* the bulk of the living mass issues through the one large orifice, and can spread out in a similar manner to the free *Amœbina*,—the shell, according to the direction of the pseudopodes, resting in the centre of the mesh or on one side. The *Foraminifera* have a like capacity of extruding their processes in one direction rather than in another, or in all directions together; and accumulations of their mucous substance, or fusions, may take place on any one side. In this family the filiform fibres are, as a rule, not seen protruded at any one time through all the pores perforating the shells.

Many genera have, besides the generally-distributed small foramina, a larger orifice in the ultimate chamber; such is seen in *Rotalia* and *Textilaria*. In these, says Schultze, it may be remarked that the processes first thrown out come principally from the large openings, and frequently a considerable time elapses before the numerous fine pores give exit to fibres. Often, again, the filaments are extended only from the two or three last-formed cells. Yet after long lying undisturbed, fibres may be seen proceeding from every part of the surface of the finely porous shells. Still the question requires further examination, to decide whether the processes can be extruded through all the foramina or only through some of them in certain places. However, as Schultze remarks, the universal porosity would seem without a purpose if it does not give vent to the contained substance at all points.

The processes of *Polythalamia* attain the greatest length and fineness, and often constitute a network of several lines in diameter,—the shell of the animal occupying the centre, like a spider lodged in the middle of its web. The length of such fibres not uncommonly exceeds twelve times the diameter of the shell. The processes of most *Monothalamia* are not so numerous, and do not equal on an average those of the *Polythalamia*, whilst those of the *Amœbæ* are mostly shorter and broader. The length, number, and fineness of the processes, together with their mode of termination, supply, under considerable limitations, characters for distinguishing species chiefly of the *Amœbina*, and, in a less degree, of the single-chambered testaceous Rhizopoda.

The ever-fluctuating form of the animal mass and of its processes is expressed by the term "*polymorphism.*" It is, as before noticed, a well-marked character of *Rhizopoda*, although not restricted to them; for the like is exhibited by the yolk-cells of *Planaria*, and by detached fragments of the substance of *Hydra*; in fact, illustrations are not wanting in the vegetable kingdom.

The phænomenon of polymorphism would seem to discountenance the hypothesis of the presence of a limiting membrane or skin. Ehrenberg described a resistant, very elastic, and contractile integument, and, to explain the variability of figure and the extension of the pseudopodes, supposed a relaxation or suspension of the natural contractility of the integument at the extending point, and a consequent passive yielding before a pressure from within exerted by the contained substance. This explanation he endeavoured to illustrate by comparing the process with the formation of a hernia or rupture,—a comparison, by the way, involving an effort of imagination to discover any similarity between the two occurrences. Thus he remarks of *Amœba princeps* that "its normal shape, if such it can be said to possess, is globular; but it can relax any portion of its body, and contract the rest, so as to force the internal substance down into this relaxed portion, which thus becomes, as it were, a hernial tumour." This notion is opposed by the results of observation. The very characters of the processes, their great length and frequent tenuity, their branching, adhesion, and coalescence contradict the assumption; and the fact of their not uncommon extensoin from all sides of an animal involves, as a consequence of Ehrenberg's hypothesis, a belief in the exertion of internal pressure in opposite directions at the same time. Other evidence of the error of this hypothesis is found in the following facts, viz. the adhesion and entrance of foreign bodies at any part of the sarcode substance, the cohesion of two individuals, and that, as pointed out by Dujardin, when the gelatinous mass of an *Amœba* is torn or cut across, no escape of a contained softer matter or of granules takes place, but each segment contracts on itself and continues to live, and, again, that when a Rhizopod is shaken about, its processes become flexuous, and float loosely instead of being withdrawn within the general mass, as should happen if a general contractile integument enveloped it. Among the *Amœbæ* generally, a distinct hyaline cortical substance is found enveloping the interior more fluid matters, and restraining their escape. (See afterwards, on shells of *Monothalamia*, exceptional forms noticed by Dujardin and Bailey, and the researches of Auerbach.)

Although an integument be, therefore, no part of the structure of Rhizopoda, yet their soft substance is capable, as is shown best in the *Amœbina*, of resisting internal pressure, such as that from silicious shells of *Diatomeæ* and other hard substances, which oftentimes cause irregular and sharp projections during the movements of the animals, but yet very rarely perforate them. On the other hand, Rhizopoda become sometimes impaled upon the rigid fibres of plants or other substances, and, though thus transfixed, will move from one extremity to the other, without any apparent inconvenience or injury. This circumstance has been long noticed in the case of the *Amœbæ*; and Schultze has figured a specimen of a testaceous Rhizopod—the *Gromia Dujardinii*—penetrated by a large curved hair.

Dr. Auerbach, in a recent Essay on the *Amœbæa* (*Zeitschr.* 1855, pp. 365–430), has advanced the statement, from observation, that all the *Amœbæ* are enclosed by an adhesive, elastic and structureless membrane or integument. This fact has, he says, been so universally overlooked by reason of the difficulty in determining it, and, where caught sight of, has been misinterpreted, as, for instance, by Schneider (*Müller's Archiv*, 1854, p. 201), who represents *Amœba* enclosed by a membrane as being in a state of "rest," or encysted.

Auerbach makes particular reference to two new species discovered by him, as illustrative of the presence of an integument, viz. *A. bilimbosa* (XXII. 7–11), and *A. actinophora* (XXII. 13), in both of which he detected a double peripheral line. But besides this evidence he appeals to the effects of reagents, of acetic or of diluted sulphuric acid and alkaline solutions, both on the species just cited and on others well known—for instance, *A. princeps*—in demonstrating the membranous investment. And what seems at least very strange, we might say quite inexplicable, he asserts that upon all the processes, however branched, anastomotic, or fine, this membrane is extended to their very extremities; for on adding a dilute alkaline solution to *Amœba radiosa*, the granular and molecular contained mass became shrunken, and retreated towards the centre, leaving the figure of the animalcule with all its processes as before the addition, the latter appearing as tubules with closed ends, which ruptured by over-extension.

This same author accounts for the entrance of solid particles from without by imagining the integument to rupture to receive them, and then to close on them so as to leave no trace of the proceeding. Further, the membrane is not soluble, at the ordinary temperature, in acetic nor in mineral acids, nor in dilute alkaline solutions, and therein agrees with the tissue noticed by Cohn in *Paramecium* and other Ciliata (*vide* chap. on CILIATA), and with the cell-membrane of animal cells.

These observations of Dr. Auerbach are well deserving attention, although we are indisposed to accept them in their entirety. The wonderful polymorphism, the coalescence of processes, and the particulars alluded to above (p. 204) as inconsistent with the presence of an integument need not be again adduced in argument. What is desirable is, that observations should be multiplied on this subject, which is one that strongly commends itself to the notice of microscopists on account of its bearing on the question of cell-constitution.

The variable processes serve the Rhizopoda for locomotive organs. An expansion is thrown out in advance, into which a constant influx of the sarcode substance sets,—whilst in the opposite direction a counter-current occurs, effecting the retraction of the posterior processes. This onward flow of the substance of the body proceeds until at length the whole is transferred into the advanced process, moving from its base to its termination. In this manner the animal progresses, the space passed over equalling the length of the expansion it protrudes. This method of locomotion may be designated creeping or crawling, and is the only one with which this class of animals is endowed. The consequence is that they are, as a rule, to be only found adherent to solid bodies, and cannot move by swimming. However, they can move as passive particles of matter, be rolled along by currents upon any substance they are in contact with, or, from being (as in the case of *Amœba*) of almost the same specific gravity with the water in which they live, may float, or be suspended in it for a long time. Their motion by creeping is exceedingly slow, and oftentimes is appreciable only by attentive watching.

The graphic description of Schultze, of the expansion of processes in a naked *Amœba* and in a testaceous species, viz. the *Gromia oviformis*, will make the phænomenon more distinct. The former is a new species discovered and named by himself the *Amœba porrecta* (XXI. 3). It is distinguished from other species in the genus by the great extension it is capable of, and by the lively motile energy of its contractile substance. "It sends out from its colourless body, on all sides, numerous fibrous processes, short and broad on their first extrusion, but which gradually elongate until they exceed the diameter of the body eight or ten times, and taper to such fine extremities that a magnifying power of 400 diameters is needed to distinguish them. The figure and extension of the body change every moment, according to the side in which the ramifications are extended. If two or more of the filiform processes touch, a coalescence takes place, and broader plates or net-like interlacements are produced, which, in the continual changes of figure, are either taken up again into the general mass, or otherwise are further increased by a fresh influx of matter, until finally the entire body is transposed to their place."

In the testaceous *Gromia oviformis* (XXI. 16), after a state of rest of some duration, fine fibrous processes are seen to be extended from the single large opening of the shell, which, on their first extrusion, move about in a groping manner until they lay hold of some solid body (such as the surface of the glass slide) on which they may stretch themselves out, receiving in the meanwhile new matter from within the shell. The first fibres are extremely fine; but presently they grow wider, and proceed to elongate themselves, pursuing a straight course, ramifying in their own way and coalescing with adjoining processes, until, becoming progressively finer and finer, they attain a length exceeding that of the body six or eight times. The fibres having now outstretched themselves in every direction, and absorbed the greater part of the finely-granular contractile substance, their further extension in length ceases. However, the reticulations go on multiplying; numerous bridges (inosculations) are established between them; and by the continued changes of position a constantly shifting protean web is produced, where a greater number of fibres come together at the periphery of the sarcode-net as we may term it, broader plates (laminæ) of the perpetually-flowing substance are formed, from which again new filaments are pushed out in new directions, as if it were a separate *Amœba*. In the *Polystomellæ*, the long fibres are seen to converge to form a pyramidal bundle, and to coalesce into wide laminæ at its apex.

Dujardin made some precise observations respecting the characters of the locomotive variable processes and the rate of movement. In *Gromia oviformis*, he describes a filament to begin as a very fine simple and uniform offshoot, which elongates and directs itself in different directions, in order to seek a point of attachment; sometimes it oscillates, at others it exhibits a tolerably rapid undulatory movement, or, otherwise, it rolls itself up in a spiral manner, when the several coils coalesce, and a mass is formed capable of throwing out afresh other processes. Proportionately to the extension of the filament, its substance is added to by an afflux of new substance from the chief mass, evidenced by the movement of irregular granules, which give the fibres an unequal and nodose appearance. Moreover, the fibre gives off branches here and there at a more or less acute angle, which, in their turn, ramify after the same fashion, and establish communications or anastomoses with one another. Often also films or laminæ of the gelatinous substance form at the extremities of contiguous fibres, which extend themselves variously. The filaments retreat by an inverse movement; and this is occasionally so sudden that the end assumes a button-like termination from the fusion of the mass of matter engaged in its formation.

The expansions of *Miliola*, he further tells us, are six times finer than those of *Gromia*, and the movement of the animal more rapid; for during summer it moves from about $\frac{1}{13}$th to $\frac{1}{6}$th of an inch in an hour. *Cristellaria* moves $\frac{1}{5}$th of an inch, and *Vorticialis* from $\frac{1}{7}$th to $\frac{1}{3}$rd of an inch in a like period.

The variable processes also constitute the prehensile organs of the Rhizopoda. Any small objects serviceable for nutrition, with which they come into contact, are laid hold of by them apparently by means of their viscid surface; and, except they are animalcules of considerable size and power, they are unable to escape. When a filament or, as we may call it with reference to this function, a tentacle has so seized its prey, adjoining fibres aggregate about it and coalesce, a current of the viscous substance sets in towards the spot, and very soon envelopes the object by a film. The prey being thus secured, the processes shorten themselves and draw it towards the chief mass or body of the animal, or, otherwise, the object seized continues in the same place, and the whole organic substance moves towards it,—the result being in either case that it is engulfed. In the *Amœbina* this prehensile act proceeds as just stated; in the *Monothalamia* and in those *Foraminifera* having a large opening in the last chamber, the body seized is directed to the large orifice of the shell; but in those having no other than fine pores or minute fissures, it would not seem to reach the general mass, but to be used up for the purposes of nutrition externally to the shell, by a digestive action inherent in the fibres themselves. The mode of entrance, therefore, of food within the viscid organic matter, is not so simple and mechanical an act as Dujardin represented it, but has much more of a vital character. This observer's statement was, that the mere pressure of the body of the animal on the surface it moved over caused the penetration of foreign matters, which, by subsequent extensions and contractions of different parts of the substance, became at length completely involved in it. It would seem that animalcules may swim about unharmed within the meshes of the sarcode-web, but that so soon as they touch one of its fibres, they are as it were paralysed and incapable of further motion, and are consequently drawn deeper into the net without any opposition. Schultze, who has noticed this circumstance, believes it to be quite explicable as a simple mechanical act, and no proof of a special benumbing property resident in the soft substance as Ehrenberg was inclined to suppose. Food, or indeed any extraneous matters, may enter the soft bodies of Rhizopoda at any point of their surface; *i. e.* in other words, those animals have no definite aperture for food—no mouth. This absence of a mouth, on anatomical grounds alone, involves that of an alimentary canal, or of a polygastric structure such as Ehrenberg imagined. The digestive cells, so called, of *Arcellina* are nothing more than hollow spaces or vacuoles (XXII. 7, 8, 9), which spontaneously and irregularly develope themselves in the mucous sarcode substance. They especially make their appearance after the introduction of food, the particles of which generally appear enclosed within them, and to be surrounded by a fluid. In the allied organisms represented by *Actinophrys*, M. Claparède states that the particle of food *always* lies in a cavity filled with fluid—a vacuole,—and that the fluid is of a pale reddish colour, with different refractive powers to those of water, and is in all probability a solvent or digestive fluid. This pale-red or reddish-yellow tint of the vacuoles is remarked also in *Amœbæ*; and the observed dissolution and eventual disappearance of organic matters absorbed is a sufficient proof of the presence of a digestive secretion. In an *Arcella vulgaris*, Perty witnessed the successive appearance of four vacuoles, each in its turn enlarging from a small round to a large reniform space, and thereby expanding the dimensions of the animal itself. He believed them to be filled with air, and, like the air-bladders of fish, to serve to float and turn the animals in the water, when free and without solid objects to crawl upon.

Ehrenberg states that in some *Arcellina*, where "digestive sacs" were otherwise invisible, they were brought into view by feeding the animals with coloured substances. He thus presumed on the prior existence of these cells, supposing the colouring particles to be merely the means of bringing them into view. The true explanation, however, is, no doubt, that the construction of vacuoles is consequent on the introduction of food, and dependent on the manner in which the animal substance enfolds the solid particles which it has seized. Observation, indeed, proves that the vacuoles have no constant and definite existence and position; for they collapse and disappear when the contents are removed or are reduced to a few fine granules dispersable in the common mass. They also constantly shift their position, and not unfrequently make their way to the surface, at which they burst and disappear. As Dujardin also remarks, they sometimes form at or near the surface, and may even serve as a medium for introducing foreign matters into the body.

Dr. Bailey, in his description of a new species which he names *pamphagus*, represents it as having (although a shell-less Rhizopod) a mouth from which alone pseudopodes protrude, and a single stomach; hence, he adds, it cannot be considered *polygastric*. However, no evidence is adduced to support this notion of a gastric cavity; on the contrary, indeed, the details given stand opposed to such an hypothesis,—for instance, to quote only one, that of their being frequently seen transfixed by delicate fibres of foreign matters, and moving unharmed up and down them.

Schultze states that in *Foraminifera* very clear vesicles are uniformly diffused throughout the body, some entirely homogeneous, others finely granular, or filled with corpuscles. However, nuclear corpuscles, which can be regarded as cells in the ordinary signification, are never found. This naturalist, moreover, indicates the existence of a larger species of vesicles in *Gromia oviformis* (XXI. 16), containing other clear corpuscles, sometimes to the number of eighteen, but never strung together; he believes likewise that similar vesicles exist among other *Foraminifera*, and seems disposed to attribute to them a nuclear character.

Ehrenberg professed to discover in the *Polythalamia*, in each chamber, saving the last, an alimentary tube, having a greyish-green colour and very thick. This intestinal cavity, he affirmed, communicated with the cell in front, and the one next behind it by a narrower canal—the siphon,—and that in this manner a sort of continuous moniliform intestine was produced, extending from the primary to the penultimate cell. He adds that, after the solution of the shell of *Nonionina Germanica* by dilute acid, various silicious Infusorial shells could be seen within this digestive tube, as far back in the animal as the first chamber. Moreover, he was fortunate enough to be able, after the dissolution of the shell of *Rotalia* by acid, and by proceeding very gradually, to set free an internal, spiral, jointed body, the segments of which were strung together in *Nonionina* by one, and in *Geoponus* by from 18 to 20 tubes (siphons); strong acids destroyed the shell so rapidly that the contained delicate body became broken up into many insignificant fragments. In none did he succeed in introducing coloured food. This digestive apparatus others have sought in vain in the *Foraminifera*. The spiral articulate body extracted by the Berlin naturalist from the shell, was undoubtedly nothing more than the soft animal contents, somewhat acted on by the acid, such as Schultze has pictured from the cavity of a *Miliola* (XXI. 24).

Respecting the penetration of food to the primordial chamber, which Ehrenberg imagined he had seen in *Nonionina*, Schultze observes that, among the many beings he has examined, he has not detected nutritive matters further back than the second or third cell.

The substances received from without, after having served their purpose within the gelatinous body of Rhizopoda, make their way outwards and escape from any part of the surface,—an anus being, like the mouth, produced temporarily, at any point whatever, where matters present themselves for discharge.

The materials taken within the body of Rhizopods are most heterogeneous; no selecting power being displayed by the animals, various Ciliated Protozoa, fragments of the filaments and spores of Algæ, frustules of *Diatomeæ* and *Desmidieæ*, even *Rotatoria*, fall a prey: but along with these, from which nutriment may be extracted, are other substances which can be supposed to serve no useful purpose; such are particles of sand, morsels of woollen and of cotton tissues, and the like. The introduction of particles indiscriminately is explicable from the mode in which they are captured by the filamentary arms, which seem to act in a prehensile manner, on feeling the contact of any foreign object, be that what it may.

Dujardin threw doubts upon the nutritive purpose of the solid objects swallowed, and supposed the act of nutrition consisted in the simple imbibition or endosmosis of fluid from without. "It is," he writes, "difficult of belief that these included particles, by reason of their consistence and the unalterability of many of them, can serve to nourish the *Amœbæ*; yet, whilst admitting that they are nourished by absorption, I would not deny that they may find means of still more readily appropriating nutritive materials, by swallowing various foreign bodies, and by so increasing their absorbent surface." The evidence of direct observation, however, is in favour of the conclusion that the substances received within the simple animal mass actually afford materials for its nutrition. The contents are ever changing and making their exit from it; and an act of digestion or of solution is perceptible—slow, indeed, even when soft Ciliated Protozoa are the subjects. Thus animalcules, when within the sarcode mass, are first compressed into small balls; the distinctness of their parts then fades, and they are presently converted into small gelatinous globules, which in due course disappear, from amalgamation with the enclosing substance. Where the included body consists partially of insoluble material, this remains behind in the form of fine granules, or, in the case of the silicious-enveloped *Diatomeæ*, the dense skeleton, emptied of its organic contents, continues visible for a longer or shorter time. The robbing of the frustules of Bacillaria, and the appropriation of their coloured endochrome, has been referred to in the foregoing remarks on the colouring of Rhizopoda (p. 203) by the green colouring-matter of plants.

The Rhizopods Bailey describes were met with in a vivarium, into which "bits of boiled beans and potatoes had occasionally been introduced as food for other animalcules;....on the application of tincture of iodine to these animals, a distinct blue colour was often seen diffused over the whole surface of many of the grains of sand in their stomach."

The above facts—to which we may add another, viz. that the abundance of granules in the interior is in direct proportion with that of food—furnish sufficient proof of the occurrence of a digestive faculty, and of a power of assimilation among the Rhizopods. This implies the existence both of a digestive fluid, and of a secretory function; the latter, too, is further exemplified by the production of shells in the majority of the class.

Auerbach (*op. cit.* p. 422) distinguishes two leading varieties of granules in *Amœbæ*:—one of a pale colour and finely divided, and either soluble in alkalies and acids, and turned brown by iodine, or, more rarely, insoluble in alkalies; the other, dark in hue, strongly refracting, and usually correspondent in number and relative size with the animalcules to which they appertain. These latter have the aspect of fat-molecules; are spherical or elliptic, or at times crystallized in a rhombic form; and they are easily soluble in cold alkaline solutions, and more slowly so in concentrated acetic and sulphuric acids. In one species, *A. bilimbosa*, he met with starch globules; but these were probably of extraneous origin.

Movements of contained particles.—Every movement of the mucous substance of Rhizopoda is accompanied by one of the granules, and of the small vesicles or globules contained within it. This motion of the contents follows a certain course, and is especially observable in the outstretched variable processes. Schultze thus describes it in the large *Amœba porrecta*:—"A continued current of the granules, imbedded in the contractile substance, accompanies all these phenomena (viz. of *polymorphism*); and, in the processes, this current follows two directions; thus the globules may be seen advancing on one side, towards the end of the process, when they turn round to the other, and are carried with a comparatively more rapid motion back towards the base of the filament, where they are lost in the substance of the body, unless they happen to meet another stronger stream by which they are reconveyed through the same circuit." A precisely similar phenomenon is witnessed in the testaceous Rhizopods. Thus in *Gromia oviformis*, Schultze says, the granules are seen to depart from the substance within the shell to the end of the filaments, and thence to return again to the point from which they set out. This circulation goes on in every process; but it is in the broader filaments, containing numerous granules, that the double stream is chiefly visible: for in the finer ones, whose diameter is often less than that of some of the corpuscles, it is more rarely seen; in fact, in the latter the granules seem not to be included within the substance, but to be transported on the surface. Oftentimes a corpuscle, on arriving at a point where a fibre bifurcates, is arrested for a time, until drawn into one or other current,—whilst at the bridge-like connexions between adjoining filaments, where the granules pass across from one to the other, it not unfrequently happens that they are transferred from a centrifugal to a centripetal stream, and are consequently turned back again towards the body. Moreover, in the broader processes, granules are observed to come to a stand, to oscillate for a time, and at length to take a retrograde course. Since there is no appreciable distinction of tissues, not even of integument and contents, the existence of vessels to account for these currents cannot be presumed.

A curious exception appears to exist in *Gromia Dujardinii*, the filaments of which exhibit no granules, but are perfectly hyaline, and moreover show no circulation. In their transparency, Schultze remarks, they resemble the processes of *Arcella* and *Difflugia*, and so also in the matter of breadth, but differ by their greater length, their finely-pointed extremities, and by their frequent ramifications. This species has also in its principal mass peculiar corpuscles, round, oval, or irregular in figure, with a sharp outline, and of a brown colour, differing from all other known elementary particles in chemical reaction, in resistance to alkaline solutions, and to mineral acids, even to sulphuric.

Amid the many shifting corpuscles and small globules is a large vesicle, constant in position, alternately collapsing and dilating, and hence called the *contractile vesicle* (XXII. 4, 5, 6). This organ, which is homologous with the pulsating sacs of Ciliated Protozoa, has not been remarked by every observer, nor in many of the Rhizopoda; nevertheless we presume it to be an essential organ, and its existence general in the class. In *Arcella* a contractile vesicle has been seen by many; in *Actinophrys Sol*, Claparède has satisfactorily proved it a true sac, having a resistant membranous wall, and has counted as many as ten such vesicles in *Arcella vulgaris*; Auerbach treats of the vesicle as general among *Amœbœa*; on the other hand, Schultze was unable to discover such an organ among the many *Foraminifera* he examined.

Nucleus.—Another definite body is mostly discoverable in Rhizopods, viz. a *nucleus* in the form of a more or less rounded or oval body, more opaque than the rest of the contents, and consequently more solid in appearance (XXII. 4, 5, 9, 16, 20). In *Amœba* and *Arcella*, Ehrenberg and Siebold admitted the existence of a nucleus; Schneider says that *Amœba diffluens* and *A. radiosa* possess one, that a round reddish nucleus having a white nucleolus is present in *Difflugia* at its hinder end (XXI. 19 *a*, *b*, *f*), and that probably all the Rhizopoda have such an organ. Kölliker, to whose hypothesis of the cell-nature of Rhizopods the recognition of a nucleus was of much importance, remarks, "with respect to the nucleus, it really appears to be present in some of them (see Ehrenberg's figures); and where it is wanting, as in *Actinophrys*, a true nucleus may have existed at an early period, and be absent only in the full-grown animal, or, again, it may be entirely wanting, and still the animal be regarded as a cell."

Claparède, on the contrary, denies a nucleus to the naked Rhizopoda, at least to *Amœba diffluens*; and likewise to the testaceous species, such as *Arcella*. However, he admits that the usual opacity of the shell is an obstacle to an accurate determination of the question, and remarks, concerning the foregoing supposition of Kölliker, that there is no evidence of its truth, and no foundation in fact.

Schultze has encountered an undoubted nucleus in nine different species of *Amœba*, in *Difflugia proteiformis*, *D. acuminata*, and *D. Helix*, in *Arcella vulgaris* and several species of *Euglypha*. In *Gromia oviformis* a round, clear, delicate body filled with very transparent small vesicles may always be found. In old full-grown individuals not one but several such bodies are seen at the posterior part of the animal, all of equal size and of similar structure (XXI. 12, 13, 14). In one specimen as many as eighteen of these nuclei were counted. In young small *Gromiæ* only one nucleus is seen; in a solitary instance two were found.

In *Difflugia proteiformis* usually several (8 to 12) nuclei are perceptible, as in *Gromia oviformis*, in the posterior portion of the shell.

The nuclei of freshwater Rhizopods either appear to be homogeneous delicate elastic globules, here and there finely granular, or they resemble the nuclear body of *Gromia oviformis*, and consist of a group of small vesicles or globules enclosed by a common membrane (XXI. 14).

The single nucleus of young beings, Schultze supposes to be derived from the parent animal; and he further presumes that, in the course of age and growth, this organ is capable of multiplying itself, and may, moreover, serve as a centre around which the fine granules of the living contents aggregate, and that, after the formation of an enclosing membrane, an embryo is generated from it. On the other hand, this careful observer was not able to discover a nucleus in *Foraminifera*, and admits that the above suppositions are highly doubtful.

In a large specimen of *Gromia Dujardinii*, Schultze met with certain enclosed bodies, having a firm shell and granular contents, and only wanting a mouth to complete their resemblance to the parent animal (XXI. 18 *a*, *b*). He also cites, as still more questionable examples of a nucleus, a clear spot in the first chamber of *Rotalia veneta*, and in *Textilaria picta*, a finely-granular, solid, and nucleariform body in each of the two last cells (XXI. 32).

On this point, the presence of a nucleus in *Foraminifera*, we have the statement of Ehrenberg, that in each cell, except the last, there is a coarsely granular yellowish brown mass, which represents an ovary in structure and function. Unfortunately, however, the Berlin microscopist stands alone, both in this observation and in its pendent corollary. Dr. Carpenter uses the word nucleus to signify the primordial mass of sarcode seen in the first cell, of which all the subsequent chambers and their contents may be deemed the offshoots.

Scattered among the amorphous granules of the sarcode are, for the most part, numerous refracting corpuscles of less size than vacuoles, which are soluble in ether, and therefore concluded to be fat-globules (XXI. 14–16). There are also other molecules dissolved by caustic potash. It is these various globules and granules that some observers have esteemed to be ova, without, however, any countenance from facts for the supposition.

To recur to the naked Rhizopoda, Auerbach, in the essay before quoted, attributes a nucleus to the *Amœbæa* in general. He remarks that the solid-looking organ, of a dull aspect and commonly spherical figure, noted by certain authors in some *Amœbæ*, is rather the nucleolus than the nucleus, and that the latter is perceptible in the form of a hollow space, oftentimes having a glistening rosy hue, which surrounds the other like a sac (XXII. 4, 5, 9, 10, 11). This sac is sometimes visible as a dark areola, but at others requires the operation of chemical reagents to reveal it, or will manifest itself in dead specimens when all the ordinary vacuoles have disappeared. At times, both it and its nucleolus have a dumb-bell figure, and thereby indicate the occurrence of the process of self-division. A similar nuclear sac is mentioned by Schneider.

As to its chemical relations, Auerbach found that both nucleus and nucleolus were readily soluble in alkalies, and that they became darker in dilute acetic or sulphuric acid, which also caused the precipitation of a finely-granular matter in the vesicular or saccular nucleus. In concentrated acids they first expanded, and were subsequently dissolved. The generally-assigned character of the nucleus, viz. that it becomes darker on the addition of acetic acid, is true only when dilute acid is used.

Auerbach discovers a nucleus and nucleolus in *Arcella*, similar to those of *Amœbæ*, often displayed when, by a fracture of the shell, the animal contents escape. The nucleus has the form of a thick-walled sac, and encloses a large nucleolus. But it is remarkable that, whilst one or at most two nuclei only are discoverable in *Amœbæ*, several such organs are frequently present in *Arcellæ*, their number being in direct proportion with the magnitude of the animals. In large specimens, of $\frac{1}{6}'''$ in diameter, above 40 such nuclei have been encountered.

Reproduction of Rhizopoda.—This function is not satisfactorily made out, especially in the case of the *Foraminifera*; what is known will best be detailed of each family separately.

Among the *Amœbina* self-division has been noticed by Ehrenberg to occur in the *Amœba princeps*; and Dujardin remarks that "they may doubtless multiply by spontaneous fission, or by the throwing off a lobe which immediately commences an independent existence." This separation of a portion of their substance is not unusual, as, when a large variable process has been shot out far from the chief mass and become enlarged at the extremity, the expanded end retains its position, whilst the portion connecting it with the body becomes finer and finer by being withdrawn into the parent mass, until it at last breaks across, leaving a detached piece, which immediately on its own account shoots out processes, and manifests an independent existence. This phenomenon is therefore one of simple detachment, and cannot rightly be called a process of fission. Schneider terms it "propagation by gemmation," and supposes it attended by a division of the nucleus, of which every such offset, in his opinion, includes a portion. This same observer further states that *Amœba* has actually a "state of rest" (*i. e.* an encysted condition). He observed it first to become round, and then to form a firm membrane on one side, whilst the other portion continued its peculiar character and movements. By degrees the membrane extended itself over the whole body, the moveable portion constantly becoming smaller, until at last a completely-closed cyst was produced, in the clear interior of which a round nucleus, with a reddish halo, exactly like that of *Polytoma* and other *Monadina*, might be distinctly observed. He adds—"In the nucleus of *Amœba* I have often noticed on the outer surface of the reddish halo, granulations which united to form a closed membrane, whilst at other times the nucleus exactly resembled that of *Polytoma*" (*i. e.* was without an enclosing membrane). What is the next phase of development following this encysted stage, Schneider has nothing to show.

If Lieberkuhn's observation be correct, a most extraordinary relation subsists between *Amœbæ* and *Gregarinæ*, involving the existence of the former as a distinct class of animated beings. This observer saw the production of *Amœbæ* from *Navicellæ*, the origin of which from *Gregarinæ* is as good as proved; and also met with such *Amœbæ* in every transition to perfect *Gregarinæ*. This fact is alluded to in a paper by Kölliker (*J. M. S.* i. p. 212), who believes the *Anguillula*-like animal noticed by Henle, and termed by Bruct *Filaria*, to be an Infusorium allied to *Opalina Proteus*, and goes on to say that the transition of this presumed *Filaria* into a *Gregarina*- and finally into a *Navicella*-receptacle is nothing extraordinary. Auerbach asserts the encysting process to be shared in by the *Amœbæa* along with other Infusoria; but he looks upon Schneider's recorded instance as an erroneous conception of a specimen clearly enveloped by an integument.

Monathalamia would seem capable of multiplying themselves like the *Amœbina*, by detaching portions of their substance, *i. e.* by a species of gemmation. Peltier has described this occurrence, although Ehrenberg failed to detect it.

Reproduction by positive complete fission is opposed by the existence of the shell, which is a product from the surface of the animals adapted to their outline, and increasing only in proportion with the augmentation of the animal substance.

The cohesion of two or even more *Arcellina* by means of their gelatinous substance, and often with the near approximation of the orifices or mouths of their shells, has been remarked by many observers, who for the most part have pronounced it a sort of "conjugation," a true reproductive act. Cohn has indeed designated it "copulation," and states it to be a general phenomenon among Rhizopods. He affirms that he has many times seen two *Difflugiæ* with the mouths of their shells so firmly connected, that strong shaking of the water about them failed to detach them; and that likewise one shell was often empty, and the contents of the two aggregated into a globular mass in the other. Leclerc, the first describer of *Difflugiæ*, in 1815, noticed a like cohesion between two individuals of *Difflugia Helix*; and Cohn, moreover, is able to confirm the fact represented by Perty of the cohesion of a brown and of a pale shell together.

Schneider has likewise noticed this adhesion of two animals, and thus speaks of it:—"True double animals of *Difflugia Enchelys* are frequently met with (XXI. 19 *f*), two bodies with membranous cases and nuclei being attached to a common foot. The foot very often consists only of a thin thread, but in other cases it exhibits all the forms which have been described as belonging to the foot of the simple animal. Both bodies are well filled with food. Three, four, or five bodies are frequently seen hanging together in the same manner; these, however, are by no means in the same plane, but stand out from the foot in various directions. If these animals are obtained in considerable numbers, the formation of these colonies by gemmation may easily be observed. The foot is seen gradually to increase in size, and acquire an oval form. A new investing membrane and nucleus are then formed. The offset is always equal to the parent-animal in size. Like the foot of a single animal, the common foot of two or more is, as might be supposed, still in a condition to form offsets." This adhesion Schneider prefers to consider an act of gemmation rather than of copulation, and supposes its occurrence among other Rhizopoda. He adds, "with Perty and Cohn I have also seen a pair of the *Arcella vulgaris* attached to one another by their openings, of which one (as was observed by those naturalists) was provided with a white, the other with a yellow shell. The white shell is probably newly formed, and therefore indicates the young specimen produced by gemmation from its companion."

An aggregation of the animal contents of a Monothalamous shell, such as Cohn noticed in one of the two coherent *Difflugiæ* and attributed to an act of conjugation, Schultze has seen in Rhizopods, quite independently of that phenomenon. In *Lagynis Baltica*, he states he has frequently seen the contents collected into a ball, having a clear speck in the centre, and situated at the posterior end of the shell, without trace of extended fibres; and he adds, "the origin of this globular mass may be followed in a great number of individuals. The posterior portion of the transparent body of the actively-moving animal gradually becomes darker, owing to the advancing development of numerous molecular and strongly refracting particles. In the midst of this dark portion a clearer spot is always visible, although it cannot be isolated or more intimately examined. By degrees the dark portion encroaches upon the entire substance of the body, and at last fills up the whole posterior portion of the shell, the body of the animal thus seeming to shrivel up into the ball-like mass described." This process, observed in numerous individuals in different stages, Schultze never saw accompanied by a connexion between two animals; and he was not able to discover what subsequent changes awaited the spherical body produced.

The phenomenon just considered appears to us to be analogous to the encysting process recounted by Schneider in the case of *Amœba*, and by Stein in so many Ciliated Protozoa.

Two other probable modes of reproduction are briefly noticed by Schneider, but require to have their existence confirmed by further observations. "I have observed," he says, "another mode of propagation in our *Difflugiæ*; and although my observations have certainly not been frequent, they have been sufficiently satisfactory. After I had kept a great number of these creatures for some weeks in a clayey sediment, the substance of the body in all the individuals contracted into a ball. All foreign substances had previously disappeared. The ball, which had a fatty outline, then divided into two and four parts; but the nucleus could not be traced during this process (XXI. 19 *d, e*). This investing membrane fell to pieces, and the little spheres which may perhaps be regarded as four quiescent spores, were no more to be seen.

"Whether another circumstance observed by me has any connexion with the reproduction of *Difflugia* must be ascertained hereafter. In all the individuals of *Difflugia* contained in one vessel, the substance of the body became converted into granules closely packed together, the form and the investing membrane being retained (XXI. 19 *c*). I often saw these granules in quick molecular movement in the interior of a sac, which appeared to be formed from the outermost layer of the body, but I watched in vain for any issue to this; after moving about for about half an hour, the granules always became quiescent again."

A note by Perty must not be omitted, although no considerable importance can be assigned to a solitary and ambiguous observation. That naturalist tells us he "once saw two round motionless animals within an *Arcella vulgaris*, each having a much greater diameter than the mouth of the shell containing them. Were these," he asks, "young beings to be set free on the death of the parent and the breaking up of the shell?" A somewhat similar fact is recounted by Schultze of *Gromia Dujardinii*, in one large specimen of which he found several oval bodies enclosed possessing a firm envelope and granular contents, and representing in every respect young *Gromia*, except in having no evident opening in their shell, which, however, may possibly be formed when set free from the parent (XXI. 18).

That the purpose of the nuclear bodies in *Gromia oviformis* (see p. 211) is not connected with the function, Schultze feels compelled to assume, principally from the absence of such nuclei in Rhizopoda generally, and from his having failed to observe their undergoing those changes known to occur in true nuclei when the generation of new individuals is in progress.

Young *Arcellina*, when first recognizable as such, have the general form of older individuals; but their shells and tissues are much more transparent, and at first colourless and without granules. But it is very probable that the young of many *Arcellina*, when first thrown off from the parent, are naked—destitute of shell,—a view supported by an observation of Cohn, who records having seen, amid the slimy matter about living *Difflugiæ*, a large number of peculiar animalcules consisting of a contractile greyish or brown finely-granular substance, about $\frac{1}{50}$th of a line in diameter and upwards, of a round, ovoid, or angular outline, and having a muco-gelatinous envelope, through, but chiefly at one end of which several fibres were extended. At a still earlier period these young beings may therefore be presumed to have been mere sarcode-like particles or minute *Amœbæ*. If this be so, some ground may be said to exist for the hypothesis of certain naturalists, who esteem the *Arcellina*, and even the *Foraminifera*, to be a more advanced stage of existence of the simple naked *Amœbina*.

Schneider hints at the possibility of a still greater transformation in the case of his *Difflugia Enchelys*. He writes—"A Rhizopod occurred in company with *Polytoma* (see p. 136), the description of which will show how very readily it might be supposed to be produced by a metamorphosis of the latter animal. Unfortunately I cannot confirm this supposition, and must confine myself to recording the fact."

Foraminifera.—It is very questionable whether the Many-chambered Rhizopods can reproduce themselves by offshoots after the manner of *Amœbina*, and *Monothalamia*; and, in short, nothing certain is known as yet of the modes of propagation of this family.

A group of figures occurs in Schultze's illustrations of *Polystomella* (XXI. 39) which bear on this point of the possible production of new beings by detachment of sarcode matter. The description of the figures informs us that some of the sarcode-globules, separated from the chief mass by pressure, have the tendency and power to throw out from themselves contractile variable processes. They exhibit a finely-granular delicate semifluid tissue, containing many flat globules and large coloured vesicles. Other portions, pressed from the general mass, are almost exclusively composed of colouring-particles, derived from the inmost part of the shell; such become entirely free, or otherwise continue attached by a sort of pedicle.

In the following examination into the modes of development of *Polythalamia* we are greatly indebted to Schultze's valuable monograph. Dujardin mentions seeing in some *Truncatulinæ* the grouping of the contents of the chambers into spherical masses, comparable to the green bodies in *Zygnema*. Schultze, moreover, encountered, in a deposit of living *Foraminifera*, along with numerous empty shells of *Rotalidæ*, several wholly or partly filled with black globules, the appearance of which suggested their connexion with the reproductive process. Repeated observation showed that these globules differed in size, but mostly had the diameter of the siphon intervening between the several chambers, or of that of the opening of the last cell. They occupied either every segment of the shell, when those of the innermost were smaller than those of the outer compartments, or otherwise they occurred in only one or two of the ultimate chambers. Every intermediate condition was met with between these two extremes. The globules were composed of a collection of dark molecular corpuscles not enclosed by a membrane, but proved by pressure to be an aggregation, held together by some sort of delicate tissue. They were unacted on by sulphuric, nitric, and by hydrochloric acid, and by boiling alkalies.

The ordinary animal substance coexisted in some of the chambers of an animal when others were occupied by these black balls; but in such instances no outstretched fibres were seen. These structures must be derived either from without as foreign matters, or otherwise be the result of a metamorphosis of the sarcode matter. The former supposition is discountenanced by their appearance, by their resistance to reagents, and their presence even in the inmost chambers. On the latter supposition they are either the result of decomposition of the substance, or they are physiological products, probably of the transformation of the entire body into germinal masses. The former origin is opposed by the direct observation that such bodies have never been encountered among *Foraminifera* in course of breaking up or of decomposition. As to the second mode of origin, they bear an analogy to the germinal elements of *Gregarinæ*, viz. to the *Navicellæ* developed from the contents of those animals, and to the brood of germs developed out of the contents of an encysted *Vorticella*: and it may so happen with the *Foraminifera*, that their entire substance is resolved into germs; indeed, a progressive formation of such germs is intimated by the circumstance of the ultimate chamber being the last to become completely emptied.

Although, therefore, the figure and size, the peculiar and successive emptying and distribution, the evident periodical appearance in the spring, and the analogy of other Protozoa speak for the hypothesis of these globules being reproductive germs, it must, on the other hand, not be concealed that their peculiar composition out of granules imperfectly bound together and enclosed by a membrane, and their remarkable resistance to the strongest acids and alkalies, are facts opposed to this supposition. Hoping to elucidate their purpose, Schultze, in some few cases, isolated those shells filled with these black balls, but, after keeping them several weeks, could discover no change in them.

Ehrenberg surmised that the *Polythalamia* propagated by ova, and thought he perceived in them a sexual apparatus. On the surface of the shells of some samples of *Geoponus* (*Polystomella*) and *Nonionina*, from Cuxhaven and Christiania, he discovered stalked, yellow, membranous sacs, which he represented to be ova-sacs. When first thrown out they were soft and small, but soon swelled up and hardened in the water. Schultze also met with many specimens of *Geoponus*, at Cuxhaven, having *Cothurniæ* affixed to their shells, and of a yellow colour, which he believes Ehrenberg mistook for ova-cases.

Being so unsuccessful by direct observation in his attempts to detect the method of reproduction among *Foraminifera*, Schultze endeavoured by an examination of these beings in their earliest recognized form to gather some knowledge of it. The smallest and youngest beings he met with belonged to the families *Rotalidæ* and *Miliolidæ*. Those of the latter family have a non-porous shell, and a spherical figure exhibiting the commencement of the spiral winding which eventually extends to several turns (XXI. 20 *a*, *b*). The shell-contents are quite colourless, and present few granules. As the spiral winding advances, the contents of the first-formed orbicular cell acquire a darker colour from the appearance of fat-drops and sharply-defined proteine corpuscles; and the shell simultaneously assumes the characteristic yellow colour. The difference in size of the primary cell in different species is remarkable. Still younger forms of *Rotalidæ* occurred to him, 0·01 of a line in diameter, spherical, and colourless, with a delicate glass-like calcareous shell, through the fine openings of which fibres protruded. Others also, entirely colourless, had a second chamber superposed on the first, or even three or four; but in the latter instances the characteristic yellow hue made its appearance, and rapidly increased on further growth (XXI. 31). A striking variety was, moreover, remarked in the size of the first chamber, even in the same species; the dimensions of the second and third cells were determined by those of the first. This great variation in size considerably lessens the possibility of the certain specific determination of young specimens.

From these researches it follows, that in *Miliolidæ* and *Rotalidæ*, and probably in all other *Polythalamia*, the first appearance of the animal is in the form of a colourless spherical mass, invested by a delicate calcareous wall,—the mass consisting of a homogeneous, sparingly-granular *Amœba*-body. This first-formed cell has the faculty of producing others like itself from those portions of its sarcode substance.

Of the manner in which successive chambers are formed, we learn from Dr. Carpenter that the addition of new zones (in the *Polythalamia*) probably takes place by the extrusion of the sarcode through the marginal pores, so as to form a complete annulus, thickened at intervals into segments, and narrowed between these into connecting stolons, the shell being probably produced by the calcification of their outer portions.

Since the above account was written, Schultze has produced a supplementary sheet detailing further observations on the development of *Foraminiffera* (*Bericht der Naturforschenden Gesellschaft in Halle*, 11th August, 1855).

Having met with some large specimens of *Triloculina* $\frac{1}{8}'''$ in diameter and without a tooth in the oral aperture, he kept them for a length of time under observation. Those which remained adherent to the sides of the glass vessel for eight to fourteen days mostly became invested with a brownish slimy matter, which more or less completely obscured the view of the external characters of the shell. After some more days had elapsed, the lens brought into view a number of small, round, sharply-defined corpuscles, which loosened themselves from the soft enveloping mass, and gradually diverged from one another until some forty were visible. On removing these, and placing them under the microscope, they proved to be young *Miliolidæ*, with their process outstretched. Internally, neither vacuoles, cells, nor contractile vesicle, nor a nucleus could be detected.

The brief abstract of Dr. Carpenter's elaborate essay (read before the Royal Society, 1855) furnishes us also with the following memorandum of his views regarding the reproduction of *Foraminifera*, with especial reference to *Orbitolites*. "He is only able to suggest that certain minute spherical masses of sarcode with which some of the cells are filled may be *gemmules*, and that other bodies enclosed in firm envelopes which he has more rarely met with, but which seem to break their way out of the superficial cells, may be ova." Mr. Jeffrey's views (*Proceedings of Royal Society*, 1855) do not quite coincide. Dr. Carpenter's "idea of their reproduction by gemmation," he says, "is also probably correct, although I cannot agree with him in considering the granules which are occasionally found in the cells as ova. These bodies I have frequently noticed, especially in the *Lagenæ*; but they appeared to constitute the entire mass, and not merely a part, of the animal. I am inclined to think they are only desiccated portions of the animal separated from each other in consequence of the absence of any muscular or nervous structure. It may also be questionable if the term 'ova' is rightly applicable to any animal which has no distinct organs of any kind. Possibly the fry may pass through a metamorphosis, as in the case of the *Medusæ*."

Of the many *Amœbæ* seen in company with *Foraminifera*, the *A. porrecta* is particularly remarkable, and might easily pass for one of the latter when young and destitute of its shell; for its processes resemble those of *Miliolidæ* and *Rotalidæ* in delicacy and extensibility and in the current of granules which passes through them. This circumstance suggests the possible derivation of testaceous Rhizopoda from the naked forms; and if we recall to mind the black globules surmised to be germs, their primary transformation into A*mœbæ* is imaginable, and the whole cycle of development of *Foraminifera* becomes thereupon explicable. "However, I must," says Schultze, "confess that this change of the black spheres into *Amœbæ* is a further argument against their nature as germs, since between these granular bodies, so unaffected by chemical agents, and A*mœbæ* no intermediate link is discoverable.

OF THE SHELLS OF TESTACEOUS RHIZOPODA. *a.* SHELLS OF MONOTHALAMIA.—The family *Arcellina* (Ehr.) corresponds in most points with the section *Monothalamia* of Schultze. The Berlin Professor, however, believed that his family *Arcellina* and the *Polythalamia* belonged to entirely different classes of animals, because, as he supposed, the *Polythalamia* are aggregated animals with calcareous shells, and the *Arcellina* solitary animals with a silicious testa. Subsequent researches prove, on the contrary, that all these differential characters are wanting. Each foraminiferous shell contains a solitary inmate; and although, as a rule, of a calcareous composition, yet a genus, *Polymorphina*, is pointed out by Schultze, which, as in the instance of *Difflugia*, has its testa made up of coherent silicious particles (XXI. 38). Besides all this, the shells of *Arcellina* are not silicious, but of a chitinous nature, and the basement membrane in which the earthy matter is deposited in *Foraminifera* is the same. These circumstances, together with the homology in the animal contents both of *Monothalamia* and of *Polythalamia*, the absence of the hypothetical polygastric organization in the former, and of the imaginary internal structures in the latter, render Ehrenberg's distinction of the two families as separate classes untenable.

The *Arcellina* of Ehrenberg, and the *Monothalamia* of Schultze, do not entirely accord in respect to the genera grouped under them. Ehrenberg included in his family the genera *Difflugia*, *Arcella*, *Cyphidium*, and *Spirillina*. The last-named genus departed much from the others by having a marine habitat and a convoluted, *spiral*, porous shell,—its only real relationship, it would seem, being comprehended in the one assigned feature, its silicious lorica. On the other hand, Schultze (see tabular view of his system, p. 241), by not employing the chemical constitution of the shells as a distinctive character, includes among his *Monothalamia* calcareous, membranous (chitinous), and such silicious shells as are exemplified by *Difflugia*. The essential character employed is that of the unilocular chamber; for the other nearly general feature, viz. the presence of one considerable orifice, is departed from in the instance of the porous shell of *Orbulina*.

The shells of *Monothalamia* are of a more or less spherical figure; sometimes they are ovoid (XXI. 11, 12, 16) or pyriform (17), at others compressed in one or other direction (XXI. 8), and even at times in opposite directions, so that several faces are produced. Thus in the genus *Difflugia* the spherical outline prevails (XXI. 10): the shells are globose, or subglobose, or elongated in a pear-shape (XXI. 17), or in a club-like (clavate) manner; in *Arcella* they are frequently compressed, and assume a more or less discoid figure, mostly convex above and flat beneath (7, 8, 9). In *Gromia*, again, the ovoid or globular shape is diversified by the elongation of the portion about the mouth of the shell into a sort of neck (16). In *Lagynis* (Schultze) this tapering of the oral end developes a retort-shaped shell. In *Squamulina* (Schultze), again, the testa resembles a plano-convex lens. An exceptional form is described by Ehrenberg, under the name of *Arcella disphæra*, as oblong, almost divided into two by a central constriction. The first impression would be that the supposed species was no other than two animals coherent by the mouth of the shell; that such, however, is not the case is indicated by the next clause of the description—that one segment is nearly occupied by the large foramen. Another example of a remarkably-formed shell is afforded by *Cyphidium* (XXII. 24–27), which Ehrenberg states to be cubical, with large protuberances, giving it in some positions a four-sided or an irregular figure. Again, in the genus *Spirillina* (Ehr.) (XI. 37) and *Cornuspira* (Schultze) (XXI. 25), we have examples of spirally-rolled equilateral shells, like those of *Planorbis*. In consistence the shells of most *Arcellina* are firm, with a degree of flexibility and elasticity, and are composed of a dense membrane proved by its chemical properties to be of a chitinous nature. This shell not only resists the action of boiling solutions of the caustic alkalies and of vinegar, but also concentrated nitric and chloric acids, and a mixture of the two, also chromic acid, in the solution of which chitine itself is dissolved. Further the shell is dissolved in sulphuric acid, and, unlike cellulose, is not coloured blue by this acid. Such are the chemical relations of the testa of *Gromia* according to Schultze; and such we may presume with him are those of the freshwater genera *Arcella*, *Euglypha*, and *Trinema*.

The shells of *Difflugia* are peculiar by being composed in many species of a softer substance, to which various foreign particles, shells of *Diatomeæ*, grains of sand and the like, adhere and thereby furnish an accidental or supplementary shield to the animals (XXI. 17). The substance on which those accidental matters are affixed we may presume to be chitinous, but not condensed or hardened as in the true testaceous forms. Schultze is disposed to think that, besides merely agglutinated silicious particles accidentally, as it were, appropriated, the investing tunic has actually the power of secreting silicious molecules, represented by the smallest and most intimately adherent granules of the testa. He would also extend this hypothesis to the silicious polythalamous shells, illustrated by *Polymorphina silicea* (XXI. 38) and another newly-discovered species.

Cohn apparently saw young *Difflugiæ* in the act of building their shells. These young beings consisted of a mass of sarcode surrounded by a muco-gelatinous envelope, through which fibres were protruded in different directions. These processes, by retraction, brought to the surface of the animal various foreign particles, which had become affixed to them, and were then imbedded in the mucous involucre. At length all other pseudopodes, save those from one extremity, were permanently withdrawn, and the exterior of the animal was clothed with a layer of silicious particles, grains of sand, shells of *Cyclotella*, and of other *Diatomeæ*, many of them of a blackish or brown colour.

Dr. Bailey indicates an exceptional tunic in a Rhizopod, having much of an *Amœba*-like character, which he names *Pamphagus*. It would seem to be enveloped by an integument, which, although resistant, admits of an immense modification of figure, both from external and internal pressure, and offers no impediment to the animal transfixing itself, just as if it were a completely homogeneous jelly. "These creatures," says their discoverer, "connect the genus *Amœba* with *Difflugia*, agreeing with the first in the soft body without shell, but differing in having true feelers or rhizopods confined to the interior part of the body." Just as in *Difflugia*, they are limited to the region of the mouth. From this last-named genus, "and from the whole family of *Arcellina*, these forms are distinguishable by having no lorica or shell." A very similar tunicated amœbiform animal is described by Dujardin under the name *Corycia* (*A. S. N.* 1852), which, although clothed by a membranous envelope, can be twisted and folded in every direction by the movements and contractions of the animal, and permits the extrusion of processes from any part of its surface. In this respect it differs from the *Pamphagus* of Bailey, and certainly exemplifies a peculiar phenomenon, which, in the case of the usual variable processes with circulating contents, would not be conceivable, but become so upon the explanation of Dujardin, that they do not contract on adhesion to the surface on which the animal moves, nor glide along it in the ordinary manner, but remain free, and, as we are told, seem only to serve to change the centre of gravity of the animal. "It must, therefore," says its describer, "form a new genus of *Amœbina*," intermediate between the naked *Amœbæ* and the *Arcellina*; and in another direction indicating an alliance with the *Noctilucida*.

With reference to these peculiar beings, it is worth while to bear in mind the account given by Cohn of the development of young *Difflugiæ* and the progressive formation of the shell. To recall the particular points of interest, in the primary stage the *Difflugia* was seen covered by an integument, but having processes extruded from various parts of its surface, so far resembling the *Corycia* of Dujardin,—whilst in a later stage all processes were withdrawn, except those at the one end where the single large orifice or mouth is placed, and thus came to resemble the *Pamphagus* of Bailey.

Calcareous-shelled *Monothalamia* are represented by the genera *Squamulina*, *Orbulina*, and *Cornuspira*. Such shells are brittle, and in all essential features resemble those of the next-considered family, the *Foraminifera*.

The shells of *Monothalamia* are generally coloured. When seen, as they often may be, empty, they have an orange-yellow, a brown, or brownish-black tint. This colour is acquired by age; the younger the being the less is it, *cæteris paribus*, coloured. In the youngest, as before noticed, the whole substance and its commencing envelope are quite colourless. Most shells are also translucent or diaphanous when empty; but in others the colour is so deep, that, when filled, scarcely anything of the contained substance is discernible through them. The testæ of *Difflugiæ* are mostly opaque. The surface of the shells is subject to numerous modifications. Occasionally it is uniformly smooth; but many, which so seem when occupied by the animal, are found when empty to be really finely sculptured (XXI. 11–15).

Arcella hyalina is represented by Ehrenberg to have a smooth and colourless testa; *A. vulgaris* and *A. dentata*, one superficially divided into facettes; *A. aculeata*, *A. spinosa*, and *A. caudicola*, a delicately hispid shell. Where the intersecting lines or ridges are not sufficiently developed to produce facettes, they give rise to areolæ and an areolated or reticulated surface. The surface is beset with rounded tubercles or eminences in *Euglypha tuberculata*, and by spirally-disposed polygonal depressions (alveola) in *Euglypha alveolata* (XXI. 11). In *Difflugia acanthophora* (Ehr.) (XII. 64), the surface looks as if covered by scales laid on in an imbricated manner and in a spiral direction. The same species and *Euglypha alveolata* (XXI. 11) afford instances of testæ armed with large and strong spines. This same *Difflugia* presents likewise an example of the mouth of the shell being strongly serrated. Several *Arcellina* have small depressions or pits on their surface, which at first sight resemble pores, *e. g. Arcella Okenii*; and both this species and *A. vulgaris*, according to Perty, present very numerous striæ diverging from the centre of the closed end, and concentric circles, the outermost of which in *Arcella Okenii* are dentated, and follow the stellate expansions of the shell (XXI. 15).

Among *Difflugiæ* the shell is more often rough from the adhesion of particles of sand and of other extraneous substances (*e. g.* in *D. proteiformis*, *D. gigantea*, *D. acuminata*), but in others consists of a smooth membrane, as in *D. Enchelys*, *D. oblonga*, and *D. globulosa*. Moreover, Ehrenberg enumerated *D. ciliata*, *D. acanthophora*, and other species as having an areolated surface, *D. ampulla* as punctated, *D. dryas* and *D. reticulata* as cellular, *D. Bructerii* as rugose, and *D. striolata* as striated. He further states that *D. ciliata* has a bristle or cirrus in the centre of each posterior areola.

Where spines or other elevations of the surface—or, in fact, markings in general, exist—they may not be uniformly disposed, but be produced in larger number or of larger dimensions in some parts than in others. Thus Ehrenberg signalizes an irregular disposition of the spines in *Arcella aculeata*; and not uncommonly such processes are produced only from the vicinity of the mouth.

These examples will sufficiently illustrate the diversity of surface prevalent among monolocular shells; but these shells moreover differ as remarkably among themselves in size, figure, and character of the margin, and likewise in the relative position of their mouth, foramen, or orifice. These differences supply specific and generic characters of much value by reason of their constancy. Where the mouth has an even uninterrupted margin, it is said to be "entire." Its normal figure may be considered circular (XXI. 9). However, in many instances it is irregular (XXI. 15), or a projecting portion encroaches on it (XXI. 6). In *Difflugia depressa* and *D. gigantea* it is uneven; in *Arcella lunata*, semilunar; in *Difflugia ampulla*, ovate; in *Sphenoderia*, so contracted as to be linear. Still more frequently the margin of the aperture is dentated or spinous: examples occur in *Difflugia denticulata*, *D. lævigata*, *D. oligodon*, *D. acanthophora* (XII. 64), and *D. ciliata*, in *Arcella dentata* and in *Euglypha*. The symmetrical position of the mouth is wanting in several species; and Schlumberger elevated this variation to the importance of a generic distinction. The obliquity of the aperture—its position out of the median line—is noticed in *Arcella Americana*, *A. constricta*, *A. ecornis*, and in *A. lunata*, also in the genus *Trinema* (Duj.) and in *Cyphoderia* (Schlumberger). When the mouth appears formed by the mere incompleteness of the outline of the shell, and is without a neck or deep margin, it is often said to be truncate —in fact, the oral end of the shell is truncated or abruptly cut off by the orifice.

The shells of *Arcellina* may be fractured by pressure when the contained sarcode matter escapes through the fissures, extending itself in lobe-like prolongations, which take on the characters of ordinary expansions (XXI. 7). Since the opacity of the shell is generally an impediment to the observation of the contained matter, its rupture by pressure, or its partial solution by some reagent, as sulphuric acid, which acts upon the chitinous basis, must be resorted to in order to discover the nature of the animal mass within. With or without such preparation, it is not unfrequently seen that the living mass is not uniformly adherent to the inner surface of the shell, but is, on the contrary, detached at different parts, leaving interspaces between it and the testa, varying in size and number. These vacuities may possibly arise from the detachment of the soft matter by reason of the quantity poured out from the mouth of the shell, or otherwise from the formation of vacuoles at those points, just as often happens on the surface of an *Amœba*.

b. Shells of Polythalamia or Foraminifera.—These have a great diversity in figure and size, and are often very beautifully coloured and sculptured. From the resemblance of many to the shells of *Cephalopoda*, especially to those of *Nautili* (XXI. 28), they were for a long time ranged along with those highly-developed Mollusca. The shells of *Polythalamia* consist of a greater or less number, according to age and species, of communicating chambers or cells, aggregated together or superposed on one another in different ways, the mode of disposition, however, varying within certain limits even in the same species. Thus Dr. Carpenter, speaking of *Orbitolites*, says (*Proceedings Royal Society*, 1855),—"Starting from the central nucleus, which consists of a pear-shaped mass of sarcode nearly surrounded by a larger mass connected with it by a peduncle, the development may take place either on a simple or upon a complex type. In the former (which is indicated by the circular or oval forms of the cells, which show themselves at the surface of the disk, and by the singleness of the row of marginal pores), each zone consists of but a single layer of segments, connected together by a single annular stolon of sarcode, and the nucleus is connected with the first zone, and each with that which surrounds it, by radiating peduncles proceeding from this annulus, which, when issuing from the peripheral zone, will pass outwards through the marginal pores, probably in the form of pseudopodes. In the complex type, on the other hand (which is indicated by the narrow and straight-sided form of the superficial cells and by the multiplication of the horizontal rows of marginal pores), the segments of the concentric zones are elongated into vertical columns, with imperfect constrictions at intervals; instead of a single annular stolon, there are two, one at either end of these columns, between which, moreover, there are usually other lateral communications, whilst the radiating peduncles, which connect one zone with another, are also multiplied, so as to lie in several planes. Moreover, between each annular stolon and the neighbouring surface of the disk, there is a layer of superficial segments distinct from the vertical columns, but connected with the annular stolons; these occupy the narrow elongated cells just mentioned, which constitute two superficial layers in the disks of this type, between which is the intermediate layer occupied by the columnar segments.

"These two types seem to be so completely dissimilar, that they could scarcely have been supposed to belong to the same species; but the examination of a large number of specimens shows that, although one is often developed to a considerable size upon the simple type, whilst another commences even from the centre upon the complex type yet many individuals, which begin life and form an indefinite number of annuli upon the simple type, then take on the more complex mode of development."

Each cell is occupied by the animal sarcode substance—sometimes not completely, so that intervals exist at points between the contained matter and the enclosing calcareous wall, just as in *Monothalamia*. The first cell produced, about which all others are arranged and may be considered offshoots or dependencies, is called the primary or primordial cell; and in it is contained the mass of condensed sarcode which Dr. Carpenter calls the nucleus.

The link-like portions connecting one chamber with another are called by Schultze bridges (Brücken) or isthmi, by Ehrenberg siphons, and by Carpenter 'stolons.'

In chemical composition the shells of *Polythalamia* are calcareous, with the exception of those of *Polymorphina silicea*, which, like those of many *Difflugiæ*, are composed of small granules and tablets of silex. Schultze observes that, in addition to this species, *Spirulina agglutinans* and *Bignerina agglutinans* have their surface covered by adherent grains of sand, to give it the firmness and resistance provided for in other forms by their shells. The consequence of their calcareous composition is, that the shells are hard, brittle, and opaque, and their contents only visible so far as protruded in the form of processes. To examine, therefore, the animal matter, it is necessary to crush the shells, or, better, to carefully remove some portions and so expose the subjacent tissue to view; or they may be acted on by dilute acid, which dissolves out the earthy matter, leaving the transparent organic basis of the testa. Dujardin employed dilute acid mixed with alcohol, which contracted and rendered the sarcode substance harder, and gave it the appearance, in the many-chambered cells, of laminated or lobulated masses connected together by thinner portions.

When the calcareous earthy matter is dissolved out of the shells of *Foraminifera*, the organic matrix or basis is left as a transparent membrane, retaining the precise form and markings of the complete shell, and perforated by the characteristic pores. Its chemical relations are those of the membranous testa of *Gromia*. In thin shells the organic matter is in relatively greater abundance than in the thick ones. Acids produce an active effervescence, and so prove the presence of carbonate of lime as the principal mineral constituent. Schultze has also detected the presence of phosphate of lime, at least in some shells, viz. in those of *Orbiculina adunca* and *Polystomella strigilata*.

The shells of *Polythalamia* are commonly white, when viewed by reflected light, and when emptied of their organic contents. When the latter remain, a reddish- or yellow-brown colour is produced. Sufficiently transparent specimens and opaque fragments, viewed by transmitted light, exhibit either a glass-like (vitreous) colourless appearance, or have a brown hue. Examples of the latter condition are afforded by all solid and not finely porous shells, by *Miliolidæ*, *Ovulinæ*, and others. Moreover, the youngest, thinnest, and most transparent shells are rendered visible by their apparent intense brown colour. Amongst porous species are some, such as *Orbiculina* and *Sorites*, which have the brown colour only in stripes. Lastly, Schultze has never met with the peculiar yellow, red, and violet tints mentioned by D'Orbigny in some *Rotalinæ*, *Rosalinæ*, and *Planorbulinæ*.

The *figure* assumed by various *Polythalamia* is extremely varied, but is nevertheless reducible to certain types. We will restrict ourselves to a brief description of the primary forms established by Schultze; these are three in number:—1. In which the chambers or cells are superposed on one another in a straight series. 2. In which they are disposed in a spiral manner; and, 3. in an irregular fashion.

The *Nodosaridæ*, which have their cells placed one on another in a simple row, are examples of the first type; the *Spiroculinæ* of the second; and the *Acervulinæ* of the third (XXI. 34).

In spiral shells the chambers may be rolled in one plane, so as to form a symmetrical shell with opposite sides alike, *e. g.* in *Cristellaria*, or, otherwise, in an asymmetrical mode, so as to produce a shell like that of the common snail (*Helix*), *e. g. Rotalia* and *Rosalina* (XXI. 25–28). This latter variety may be so modified by the great elongation of the spiral, as to produce an elongated conical outline, as in *Uvigerina* and *Bulimina*, when the chambers above and below each other may present an alternate arrangement. Other varieties of the spiral are exemplified in *Orbiculina*, *Alveolina*, and *Nonionina*. In many instances a simple or regular spiral disposition is commenced in young animals, which is departed from variously as they attain the adult condition and characters. Thus in *Planorbulina* the regular spiral is transformed eventually into a completely irregular form. Lastly, the *Acervulinæ* consist of spherical or spheroidal cells aggregated into formless colonies.

With reference to the minute structure of the shell, Prof. Williamson (*Report of British Association*, 1855, p. 105) recognizes three principal types: viz.—"1. The hyaline, generally consisting of a transparent vitreous carbonate of lime, with, usually, numerous foramina. 2. Porcellanous, white, opaque, and rarely foraminated. 3. The arenaceous, mainly consisting of agglomerated grains of sand." Schultze makes two types: in the one, the shell is perforated by numerous fine pores or canals; in the other, it is homogeneous and solid. The contents of the second series are brought into relation with the external world by means of one large opening, or by many smaller ones collected in one group. This division corresponds, in the main, with that of Prof. Williamson, except that the German naturalist has omitted to notice, as a third series, those shells constituted of a membrane covered by extraneous particles of sand and the like.

The size and distribution of the foramina, along with other structural peculiarities, afford the best specific characters. To examine these details the shells must be viewed by transmitted light, and by high powers. The thick-walled opaque *Foraminifera* are best explored, as Ehrenberg first pointed out, after being soaked in some strongly refracting varnish, either entire or when cut into thin sections.

The dimensions of the canals vary in different species from ·0003 of a line (a scarcely measurable size) to ·005 of a line. They are of extraordinary fineness in *Polystomella strigilata*, in *P. gibba*, and *P. venusta*, whilst in *Orbulina* *universa* and in *Acervulina globosa* (XXI. 35–37) they obtain their greatest diameter. In the latter, and in *Globigerina*, the canals dilate towards the surface, and are consequently funnel-shaped (infundibuliform). In a few instances two different sorts of pores exist, as in *Orbulina universa* and *Rosalina varians*, the finer kind being more abundant.

A peculiar sort of slits is characteristic of the genus *Polystomella*; that they completely perforate the shell is shown by sections. They are largest in *P. strigilata*, and in *P. gibba* appear to be only shallow excavations.

Besides the openings named, the surface of the shells often presents regularly-disposed eminences or elevated lines. In *Polystomella strigilata* and *P. venusta* (XXI. 28–30) there are hemispherical or conical eminences, perforated severally by a fine opening. In *Textilaria picta* elevated lines are arranged around the widely-separated pores, so as to produce an elegant design (XXI. 25). Lastly, many shells have a spinous or stellate appearance, from the prolongation of some canals into long and fine projecting tubes, or from that of the whole of them into thick processes. Illustrations are afforded by *Rosalina Imperatoria*, *Calcarina*, and particularly by *Siderolina calcitrapoides*.

Carter has described a greenish, perishable, organic membrane as investing the entire surface of the shells with all their irregularities; and d'Archiac has assumed this to be the secreting membrane of the calcareous matter. Schultze, however, has failed to detect such a structure in every specimen he has examined, whether in a living or in a dried condition; and he observes that, even if this membrane does exist in certain cases, there are abundant facts to prove that it is not the secreting organ of the shell.

The foramina are, as a rule, uniformly distributed over the shells, those parts only being free which are placed immediately above the partitions between adjoining cells. Exceptions, however, occur. Thus, in the inequilateral *Rotalidæ* (XXI. 33) and their allies, the under or umbilical side has fewer pores than the upper. Also, in some of the thick-shelled species the position of the subjacent septa are not indicated by the absence of pores. The long winding canals pass in different directions, unite, and appear on the surface in groups, producing a complex wavy pattern on the surface, as in many *Calcarinæ*.

The partitions between the several cells are perforated by orifices, which differ in size, number, and distribution in the several species. They occur in the septa as fine pores similar to those of the surface, but in less number. Again, in species having a single large opening in their terminal chamber, there is a similar one in each partition, as in *Nodosarida*, *Miliolida* (XXI. 21, 22), *Textilaria* (XXI. 36), *Rotalida*, and in *Nonionina*, *Rotulina*, *Cristellaria*, &c. Among this group the *Conulina* form an exception, in having numerous foramina in the last cell and in the septa between the others. In *Acervulina*, again, the several cells communicate by a single opening. In *Peneroplis*, *Coscinospira*, and in *Polystomella* the septa have numerous pores; and the foramina proportionally increase in number with the increasing size of the septa, *i. e.* from the first- to the last-formed chamber (XXI. 28–30). In *Orbiculina* the thick septa are penetrated by canals.

Ehrenberg pointed out the presence, in several species, of numerous perpendicular calcareous columns interposed between the septa, which he supposed to be hollow tubes, opening up a communication between the whole series of chambers and the exterior. Both their function and their tubular nature Schultze disbelieved, and asserted that *Lunulites* (Etw.) is not one of the *Polythalamia*, but actually a colony of *Bryozoa*.

Mr. Carter (*A. N. H.* 1852, x. p. 170), on the contrary, asserts the existence of such tubes in the septa, in the following passage:—

"The septa occupy (in *Operculina Arabica*), transversely, about $\frac{1}{8}$th of the breadth of the chambers; and each septum encloses within its walls two calcareous tubes or vessels, one on each side, some little distance below the contiguous surface of the shell (fig. 7 *a, a*); these we shall call *interseptal vessels*. They are irregular both in their size and course, though generally about $\frac{1}{1900}$th of an inch in diameter, in the last-formed septa of a shell having the dimensions of the one described, and diminish in calibre backwards or towards the first-formed whorls. Each vessel commences in the centre of an intricate network of smaller ones, spread over its own side of the margin of the preceding whorl, and under the layers of the shell; these networks, which are joined together, we shall call the *marginal plexus*. In its course each interseptal vessel gives off two sets of *ramusculi*, and the marginal plexus one set. Of those coming from the interseptal vessel, one set terminates on the surface of the shell, particularly about the borders of the septum; the other goes into the walls of the shell, and through the septum, to open probably on the inner surface of the chamber, while the set from the marginal plexus opens on the margin. As this vascular system appears to extend throughout every part of the shell, and must be for the circulation of some fluid, we will call it the *interseptal circulation*."

Prof. Williamson has likewise described a series of intraseptal canals in *Faujasina*, and illustrated their arrangement by engravings. We have not space to give the details, but can quote only the general results:—"The intraseptal spaces are vertical, and give off true divergent cylindrical canals from their external margins, penetrating the thick parietes of the shell. These spaces extend from the top to the bottom of each septum, and only assume the form of canals when they approach the peripheral shell-walls. The connecting branches which unite the spaces of different convolutions are also tubular. In no instance do these spaces or their divergent canals communicate with the interior of the segments (chambers); for the only direct communications between the two parts of the organism are through the pseudopodian foramina, many of which open into the tubular portions of these passages; but never, so far as I have observed, into the intraseptal spaces." Again, "the cavities in the translucent shell are thickly lined with a dark olive-brown substance, which, if it be the desiccated soft animal, proves that in this species the gelatinous tissue has not only filled the true chambers, but has also occupied the intraseptal canals and passages. If this be so, it is curious that the only medium of communication between the soft tissues inhabiting the spiral segments of the shell and those occupying the intraseptal and central passages, should be the minute pseudopodian foramina. . . . It is, however, obvious that this organism supports the conclusion at which I arrived in a previous memoir, viz. that the soft animal had the power of extending itself externally far beyond the limits of any individual segment, and would thus be able to secrete calcareous matter in other situations than the mere parietes of its own segment. It is only in this way that we can explain the production of the dome-like covering which encloses the central umbilical cavities and their ramifying canals. But if it should be ultimately proved that the soft tissues have occupied all these irregular cavities, we shall then have a form of organization which, from its great variability of contour, will approach much more closely to the calcareous sponges than any hitherto described."

Schultze says that the species referred to by the two observers just quoted have not come in his way, but that in none of the genera he has examined has he met with a similar structure. He has been equally unsuccessful in finding the interseptal spaces noticed by Carpenter in *Nummulites*; and in no genus he has examined, has he been able to discover its shell to be composed of calcareous spicula, such as Carter represents in *Operculina Arabica*, and refers to as indicative of the intimate affinity between *Foraminifera* and sponges, in the ensuing paragraph (*A. N. H.* x. 1852, p. 173):—"It must be now generally allowed that the Rhizopodous nature of *Foraminifera* is identical with that of the *Amœba* or *Proteus*, and through the latter with the Sponge-cell; and in addition to this, we have the former, at least the genus *Operculina*, still more nearly allying *Foraminifera* to the Sponges, by possessing a spicula structure, if not a circulating system also, like that of Sponges."

The calcareous shell of Rhizopoda is lined (XXI. 16) within by a delicate organic homogeneous membrane, with a sharp outline, and of a more or less deep-brown colour. It is in immediate contact with the animal, and closely applied to the shell, and has the same perforations (XXI. 24). It penetrates from one chamber to the next through the intermediate pores and canals. During life it is, in the last-formed chambers, colourless. It is not equally visible in all species. By the addition of dilute acid to *Rotalia*, *Rosalina*, and *Textilaria*, it is readily brought into view; but in *Miliolida* this is difficult, owing to its delicacy and want of colour. In the first-formed (primordial) chamber, occupied by colourless substance, it would seem to be absent. In its chemical relations it resembles the chitinous shell of *Gromia*, and is so very slowly destroyed by decomposition, that it may be demonstrated in empty shells found amidst the sand at the sea-side, and, according to d'Archiac and Jules Haime, even in fossil specimens.

Dimensions and Conditions of Life of Rhizopoda.—The size of the Rhizopoda is very varied, even among members of the same genus. Ehrenberg describes *Amœbæ* from $\frac{1}{2800}$th and $\frac{1}{890}$th to $\frac{1}{70}$th of an inch; *Difflugiæ* from $\frac{1}{2500}$th, and $\frac{1}{1050}$th to $\frac{1}{70}$th, and *Arcellæ* from $\frac{1}{1150}$th to $\frac{1}{210}$th of an inch. Between individuals even of the same species, he represents a diversity of size of nearly equal extent. Schultze states the diameter of the shells of *Gromia oviformis*, and of *G. Dujardinii*, to be $\frac{1}{24}$th of an inch, whilst that of Lagynis is only $\frac{1}{240}$th in length. Dujardin remarks that the largest freshwater Rhizopoda attain a diameter of $\frac{1}{32}$nd, whilst the marine *Foraminifera* are for the most part visible to the naked eye, and have a length of from $\frac{1}{26}$th to $\frac{1}{9}$th of an inch. The Nautiloid shells of *Polystomella* have a diameter of $\frac{1}{36}$th to $\frac{1}{24}$th of an inch, and the irregularly-chambered *Acervulinæ* a length of from $\frac{1}{12}$th to $\frac{1}{8}$th of an inch. Among fossil *Foraminifera* larger sizes prevail: thus, Sir E. Belcher brought one species from Borneo measuring more than 2 inches in diameter; and many *Nummulites* are found an inch and upwards in diameter.

Mr. Jeffreys gives the following account of the habits of *Foraminifera* (*Proc. Royal Soc.* 1855):—"Most are free, or only adhere by their pseudopodes to foreign substances. Such are the *Lagena* of Walker, *Nodosaria*, *Vorticialis*, and *Textularia*, and the *Miliola* of Lamarc. The last genus has some, although a very limited, power of locomotion, which is effected by exserting its pseudopodes to their full length, attaching itself by them to a piece of seaweed, and then contracting them like india-rubber, so as to draw the shell along with them. Some of the acephalous mollusks do the same by means of their byssus. This mode of progression is, however, exceedingly slow; and I have never seen, in the course of 24 hours, a longer journey than a quarter of an inch accomplished by a *Miliola*. . . . Some are fixed or sessile, but not cemented at their base like the testaceous Annelids. The only mode of attachment appears to be a thin film of sarcode. The *Lobatula* of Fleming, and the *Rosalia* and *Planorbulina* (D'Orb.) belong to this division. Dr. Carpenter considers the

Foraminifera to be phytophagous, in consequence of his having detected in some specimens fragments of Diatomaceæ, and other simple forms of vegetable life. But as I have dredged them alive at a depth of 108 fathoms (which is far beyond the Laminarian zone), and they are extremely abundant at from 40 to 70 fathoms, ten miles from land and beyond the range of any seaweed, it may be assumed, without much difficulty, that many, if not most of them, are zoophagous, and prey on microscopic animals perhaps of even simpler form and structure than themselves. They are in their turn the food of Mollusca, and appear to be especially relished by *Dentalium entale*." The assumption that, because the Laminarian zone ceases at a much less depth than that at which *Foraminifera* occur, therefore no Diatomeæ are found, is quite gratuitous, and opposed to observation. The notion also that animal life furnishes nutriment to *Foraminifera* at depths where vegetable existence, and where the doubtful Diatomeæ cannot be sustained, is opposed to all probability.

Of the rate of growth and of the duration of Rhizopoda we have few recorded observations: we must, however, suppose them regulated by external circumstances, such as abundance of food, moderate temperature, and the like. Schultze observed of *Foraminifera* living in a small quantity of sea-water, so to speak, in captivity, that they grew exceedingly slowly. In only one *Polystomella* out of many, kept under observation for several months, did he observe the production of a new chamber. *Rotaliæ*, however, were more frequently seen in process of growth, the walls of the new-formed segments being extremely delicate and deficient of calcareous matter. Some very young specimens of *Miliola obesa* were found to produce two new chambers, after the completion of the primary one, in the course of four weeks.

From this fact of their very gradual growth, says Schultze, we may conclude that a year or more may elapse before the construction of a many-chambered shell is completed. This naturalist has, indeed, kept the same specimens of *Polystomella* and of *Rotalida* in captivity for nine months; and their persistence for a much longer period is highly probable. If, he adds, the production of germs put a termination to life, then this phenomenon entails a fixed limit to its duration. Dujardin, again, found *Arcellæ* alive after two years, in a vessel in which he had preserved them.

The testaceous Rhizopoda possess the power of repairing the effects of mechanical injuries to their shells. This has been proved by Schultze in the case of the *Polythalamia*; and we may conclude the same faculty is possessed by the *Monothalamia*. He has seen almost one-half of the shell of *Polystomella strigilata*, which had been broken away, repaired by a new calcareous wall resembling the normal one both in its pores, eminences, and markings. He also frequently noticed in this same species irregularities in the conformation of the shell, which he attributed to damages previously inflicted; and experiment showed him that, even on the same day that a considerable portion was removed, the animal set vigorously to work to replace the lost shell, and protruded its processes just as before.

Occasionally the destruction of a portion of the shell gives rise to monstrous (abnormal) forms. Thus Schultze noticed a double *Polystomella strigilata*, and Reuss a monstrous *Nodosaria annulata*, which he called *N. dichotoma*; and Dr. Carpenter has found several "monstrosities of *Orbitolites* resulting from an unusual outgrowth of the central nucleus."

The Rhizopoda can, doubtless, maintain life under very prejudicial conditions. The power possessed by the sarcode substance, of sustaining existence when even the greater part is torn away, and the capability of repair manifested by the testaceous species, are facts indicative of their tenacity of life.

Another proof is found in the capacity of *Foraminifera* to exist for weeks and months in the same water. Schultze states that he has found them lying motionless, with retracted processes, at the bottom of a vessel of putrid water, in which they had been kept a long time, and that when this water has been changed, or its foul odour removed by an acid, they have recommenced to move about, and to thrust out their fibres. In a small glass containing mud from the lagoons of Venice, and in which life appeared extinct, he found *Rotalidæ* and *Miliolidæ* creeping on the sides, and in great numbers in the sediment at the bottom. Some still more recent experiments have convinced this eminent naturalist that fresh water is not very detrimental to them, but that, on the contrary, they may be kept alive in it for a considerable time. He found at the same time that some dried *Polythalamia* from mud obtained at Muggia, and let dry for five weeks, continued motionless after six weeks' immersion in sea-water.

HABITATS AND DISTRIBUTION OF RHIZOPODA.—FOSSIL FORMS.—The *Amœbæ* are met with particularly in water containing much organic débris, provided that decomposition is not proceeding. They are common inhabitants of infusions, and of stagnant water, and are found adherent to foreign bodies, to plants, Confervæ, and the like. Although unable to swim, they are frequently floated to the surface on the matters to which they stick, such as dead leaves, Algæ, or stalks of plants. They occur both in fresh- and in sea-water, but are much more commonly seen in the former.

The *Monothalamia*, with reference to their habitats, form two groups,—one marine, the other freshwater. *Arcella, Difflugia*, and *Euglypha* are essential freshwater genera, whilst *Spirillina* (Ehr.), *Gromia, Lagynis* (Sch.), and *Squamella* (Sch.) are marine. They are not met with in infusions artificially prepared although common in stagnant water holding organic matters in suspension, and found crawling on these or on the sides of the vessel containing the water.

Polythalamia are all marine. Their abundance and extent of distribution are surprising; this is true of them both in the living and in the dead or fossil condition. Schultze states that on the northern level shore of the harbour of Ancona, the shells of the *Foraminifera* cover the surface here and there like a fine sand, and are discovered in many places in smaller numbers at a depth of 20 feet. When this sand was placed in water in a glass jar, no specimens were found to crawl up the sides; and observation showed that few among them retained any organic contents. From a small rocky islet in the harbour he scraped into a fine net the slimy mud, and then separated the lighter suspended particles from the mixture of animal and vegetable matter, and placed them in another glass. On examining, a few hours later, the fine sand so separated, he found it almost entirely composed of *Polythalamia*, filled with their organic substance and alive, many of them having crawled up the sides of the vessel. His experiments at Venice were entirely correspondent; no living beings were found in the sand from the shore, but countless specimens in the débris about the Algæ in the lagoons. Once, however, at Cuxhaven, on the Elbe, he met with living *Foraminifera* in the sand.

Dujardin also says of the *Polythalamia*, that, from being unable to swim, they are only to be found attached to the surface of bodies on which they crawl, such as aquatic plants, or, otherwise, lying amidst the débris covering the base of such plants, or in the hollows between the asperities of the shells of marine Mollusca. Sponges, again, form a convenient habitat for living *Polythalamia*, having their pores at times pretty well filled with them; in the same way Corals and Corallines are frequently beset with them. This necessity of attachment cannot universally prevail, since the *Foraminifera* are so often found scattered over the bed of the ocean, as well in the living as in the dead state, without any Algæ near, whereto they can adhere.

The extraordinary abundance of Foraminiferous shells in the sand of some sea-shores has been long observed. Plancus, in 1739, counted, with the aid of a low magnifying power, 6000 individuals in an ounce of sand from Rimini, on the Adriatic; and D'Orbigny states that 3,840,000 exist in an equal quantity of sand from the Antilles. Schultze also counted 500 shells of Rhizopoda in $\frac{1}{6}$th of a grain of sand collected from the Mole of Gaëta, which had previously been passed through a sieve and separated from all particles above $\frac{1}{120}$th of an inch in size.

Ehrenberg describes finding *Polythalamia* both on the surface of the sea and also at the bottom, even at a depth of 12,000 feet. From these great depths they are procured by soundings; the lead, after being coated with grease at the bottom, brings up attached to it the small particles of sand and other matters with which it comes into contact at the sea-bottom. Numerous such soundings were taken by Sir J. Ross in his Antarctic expedition, and have been practised by others in different regions. Dr. Bailey records the results of a series of deep soundings made in the Atlantic, over a considerable geographical area, from latitude 42° 4′ to lat. 54° 17′, and depths varying from 1080 to 2000 fathoms. "None of the soundings," he states, "contain a particle of gravel, sand, or other recognized unorganized mineral matter. They all agree in being almost entirely made up of the shells of *Foraminifera*. .... But neither the surface-water nor that of any depth ... collected close to the places where the soundings were made, contained a trace of any *hard*-shelled animalcules." Schultze is unable to receive Ehrenberg's statement of finding shells floating on the surface of the sea, seeing that they naturally sink in water. Still he admits that in shallow water they may be suspended by the tossing of the waves, and that they may float on the surface attached to sea-weed torn from the bottom, or to other floating substances. He likewise, and, we think (judging from the laws of distribution of organic life at different depths as pointed out by the late Prof. Edward Forbes), very justly, demurs to Ehrenberg's conclusion, that the Polythalamian shells fished up from the great depths cited, and others approaching them, lived at those depths, and had become empty by speedy decomposition of their animal contents. At depths far less considerable, we believe all organic life ceases, and should consider the Foraminiferous shells there found to have been drifted from other less profound places by currents in the ocean. Prof. Bailey also started the question, whether the *Foraminifera* found at the bottom of the sea actually lived there, or were borne there by submarine currents, but admitted that these and other like questions could not be at present decided. What, however, is very remarkable, is that the species "whose shells now compose the bottom of the Atlantic Ocean have not been found living in the surface waters, nor in shallow waters along the shore. It is but fair, also, to state that Mr. Jeffreys has dredged living *Polythalamia* from a depth of 108 fathoms (648 feet). So far as Schultze's researches go, they prove a very limited geographical distribution of some species of *Polythalamia*. Thus, he has never found the *Rotalia Veneta* elsewhere than at Venice and Muggia, near Trieste, whilst the *Polystomella strigilata*, of Ancona, is altogether absent at Venice and Trieste. *Nodosaridæ*, which are common enough at Rimini, are sought in vain at Ancona, close by, whilst *Rotalia Beccarii* occurs at both those places. So *Peneroplis planata* is found in the sand on the Istrian coast, from Città Nuova to Pola, but is absent at Trieste, Venice, and Ancona. Similar illustrations might, says Schultze, be multiplied, to show the considerable diversity of local fauna.

A limited distribution, both in reference to place and to the conditions of existence, has been determined by Ehrenberg and other observers of the *Polythalamia*, and also employed by geologists in fixing the period of the deposition of certain strata, and the circumstances under which it has occurred. Thus Bailey records of the Atlantic soundings, that they "contain no species belonging to the group *Agathistegia* (D'Orbigny), a group which appears to be confined to shallow waters, and which in the fossil state first appears in the tertiary, where it abounds." Again, they "agree with the deep soundings off the coast of the United States, in the presence and predominance of species of the genus *Globigerina*, and in the presence of the cosmopolite species *Orbulina universa* (D'Orb.); but they contain no traces of the *Marginulina Bachii*, *Textilaria Atlantica*, and other species characteristic of the sonndings of the Western Atlantic. In the vast amount of pelagic *Foraminifera*, and in the entire absence of sand, these soundings strikingly resemble the chalk of England, as well as the calcareous marls of the Upper Missouri; and this would seem to indicate that these also were deep-sea deposits. The cretaceous deposits of New Jersey present no resemblance to these soundings, and are doubtless littoral, as stated by Prof. H. D. Rogers."

A fixed geographical distribution is also implied by the division made by D'Orbigny of the species he observed,—viz. into 575 peculiar to the torrid zone, 350 to the temperate, and 75 species to the frigid zone. Moreover, Dr. Carpenter stated (in the Annual Address at the *Microscop. Soc.* 1855) that he and Prof. Williamson find "that there are certain species whose range of distribution is limited, and whose form is remarkably constant, but that, in by far the greater number of cases, the species of *Foraminifera* are distributed over very wide geographical areas, and have also an extensive geological range." Mr. Jeffreys remarks that, in his opinion, "the geographical range, or distribution of species, is regulated by the same laws as in the Mollusks and other marine animals. I have found in the gulf of Genoa species identical with those of our Hebridean coast, and *vice versâ*."

Fossil Foraminifera.—In a fossil form the *Polythalamia* are very common, and enter largely into the formation of several rocks, chiefly calcareous or of the tertiary series, in every part of the world. Ehrenberg, in his microscopic examination of the chalk formation, represents these shells as the most important constituent; and Dr. Bailey speaks of them as largely concerned in the formation of the tertiary rocks of South Carolina, and adds, they "are still at work in countless thousands on her coast, filling up harbours, forming shoals, and depositing their shells to record the present state of the seashore, as their predecessors, now entombed beneath Charleston, have done with regard to ancient oceans. For the city just named is built on a marl 236 feet thick. The marls from the depth of 110 to 193 feet are tertiary, as also, in all likelihood, are those beneath, extending from 193 to 309 feet, and also of the Eocene epoch. The lithological characters of the marls from 236 to 309 feet differ from those above them, although many of the same species are still to be detected" (*A. N. H.* 1845, vol. xv.).

The most abundant *Foraminifera* of the chalk belong to *Rotalia*, *Spirulina*, and *Textilaria*: the fossil genus *Nummulina* abounds in tertiary strata; and their shells constitute the chief ingredient in the composition of many limestone rocks used in building, such as those in Egypt, from which the huge stones of the Pyramids are quarried. In America this genus is largely replaced, as a component of limestone, by the genus *Orbitoides*. Species of *Textilaria* are the most abundant in Oolitic formations. In the cretaceous earths, says D'Orbigny, genera and species augment in rapid progression from the lower to the higher formations. On arriving at the tertiary rocks, *Fora-*

minifera become still more multiplied, and many previously unobserved genera make their appearance. In the Silurian and Devonian rocks of the palæozoic series, *Foraminifera* appear to be absent. In the carboniferous deposits D'Orbigny found one species, but detected none in the Permian, Triassic, or Jurassic strata. Mr. King has, however, discovered shells in the Permian rocks.

Many genera have hitherto been found only in the fossil state: some such we may suppose to have become extinct; but others will probably be discovered when the search after living specimens is further prosecuted. It may be generally stated that the relative number of identical fossil and recent species is much greater in this family of *Foraminifera* than in any other known; and specific forms have continued from the Mesozoic era until the present day, so connecting, as by an unbroken chain, the fauna of our own time and that of almost countless ages past.

Question of the Cell-nature of Rhizopoda, and of the Character of Foraminifera as Individuals, or as Colonies of Animals.—The prevailing theory of the cellular composition of all animal and vegetable tissues induced several distinguished naturalists to represent the Rhizopoda as cells. Kölliker ingeniously argued (*J. M. S.* 1853, i. p. 101) in favour of this view, and for a time succeeded in persuading most scientific men of its truth. It had the character of a grand generalization, and recommended itself by its simplicity. Various structural peculiarities and general considerations are, however, opposed to this theory: these we will adduce after Kölliker's arguments have been stated. He first assumes that the Rhizopoda and Ciliated Protozoa are comprehended in a single class of simple animals, which, like the *Gregarinæ*, are unicellular; and he further groups the *Actinophryina* with Rhizopoda. The absence of an integument to represent the cell-wall, and in most of them of a recognized nucleus, are difficulties he would explain away. First, he supposes that, where a nucleus is not seen, it "may have existed at an earlier period, and be absent only in the full-grown animal, or, again, that it may be entirely wanting, and still the animal be regarded as a cell." Secondly, "with respect to the membrane, it may be regarded as certain that there are cells with a membrane of such extreme tenuity as to be hardly distinguishable from the contents," and others in which at a later period all difference between the membrane and contents disappears,—for instance, the elements of the smooth muscles of the higher animals." Which of these two possible conditions obtains in the Rhizopods, he cannot undertake to say, but would remark "that their other relations are not opposed to the notion that they may be simple cells,—such as their structureless homogeneous contents, their contractility, and the vacuoles which occur in them, resembling in all respects the contents of the body of unicellular Infusoria. So, likewise, the simplicity of their form and mode of taking food, so closely resembling the way in which Infusoria introduce a morsel into their parenchyma. Certainly the presence of a cell-membrane is scarcely reconcileable with the circumstance that the body is capable of admitting a morsel of food at any part of the surface; but in one point of view it is not indispensably necessary to assume that such exists in the fully-developed *Actinophrys*, and in another it is by no means wonderful that a membrane, in consistence almost the same as the rest of the parenchyma, should be capable of being torn and of reuniting." It is therefore, he concludes, best to consider the Rhizopoda simple, although modified, cells, especially since there is little else to be made of them. "It cannot be admitted that they consist of a whole aggregation of cells; and as little is it to be supposed that they are simply a mass of animal matter without further distinction—as it were, independent living cell-contents. And the less can this opinion be entertained, because "cells are the elementary parts of the higher animals and plants, and the unicellular condition the simplest form in the animal kingdom." The existence of an investing membrane in the Rhizopoda he finally considers probable.

The arguments here quoted from Kölliker's paper on *Actinophrys*, have been examined by several later writers, and have had their defects pointed out. Perty declares himself opposed to the cell-theory since Rhizopoda are wanting the essentials of the cell-nucleus and cell-wall; and the hypothesis cannot be applied to animals composed not of cells, but of an amorphous primitive substance.

M. Claparède attacks Kölliker's arguments in detail. The question raised, whether the nucleus and membrane may not disappear in the course of growth, he answers by another query—"We may conceive the possibility of this; but where do we find any proof of it?"—and proceeds to remark his own failure, and that of Ehrenberg and of most others, to discover a nucleus, even in very small animals, and after treating them with dilute acetic acid. "The supposition, that *Actinophrys* and other Rhizopoda pass through a previous cellular condition, has consequently no foundation in fact." He cannot agree with Kölliker, that of the three parts of a cell—the nucleus, membrane, and contents—two "may be deficient,—that for example, we may attribute the signification of a cell to the contents remaining alone and contained in nothing....If, therefore, with Kölliker, we regard the Rhizopoda as a class of unicellular animals, the organisms which it includes will be principally distinguished by their having nothing to do with cells, as they consist of a shapeless mass of a structureless homogeneous substance."

M. Claparède next subjects to examination the argument for the cell-nature of Rhizopoda deduced from analogy with Ciliated Protozoa, which Kölliker takes for granted to be unicellular organisms. This assumption, and consequently the analogy dependent on it, are shown to be erroneous; and then the writer goes on to say that, "even if we admitted that *Actinophrys* was the equivalent of a cell, it would still not be unicellular, inasmuch as an endogenous cell-production has taken place in it. The contractile vesicle is nothing but a cell" invested by a membrane; and this being the case, the existence of such a membrane in other Ciliated Protozoa becomes all the more probable. "Kölliker himself supposes that the contractile vesicle, when present, is the equivalent of a cell-membrane; and with the proof of the existence of such (an endogenous) formation in *Actinophrys*, his hypothesis of the unicellular constitution of the animal consequently falls to the ground." Leuckart has also briefly argued against the cell-theory of Rhizopoda; but as no novel views are taken of the question, we shall not quote his remarks. Our own opinion is, that to insist upon the unicellular nature of Rhizopoda and of other Infusoria is to limit the operations of nature, in the manifestation of animal life, to one sort of mechanism, as though life could not be exhibited except by an organic substance enveloped by a membrane and enclosing a nucleus. Reasoning by analogy should teach us differently; for everywhere in the animal series do we see types or grades of organization progressively developed from their simplest to a more or less complicated degree, as if nature would show us by how many different plans she can attain similar and equally beneficial results. And are not the Rhizopoda an illustration of this fact, an example of the establishment of independent animality in primordial animal matter, and, as in the case of the multilocular *Polythalamia*, of the possible extent of development this simple type may undergo without the separation or addition of any other definite structural element?

If Schneider's researches be confirmed, we must admit several Rhizopoda to be possessed of a nucleus. On the other hand, a large number of species are able to produce new individuals by the mere detachment of a portion of their sarcode substance,—an act in which no nucleus is concerned, whereas in cell-propagation by fission a preparatory section of the nucleus appears a necessary process. In the Rhizopoda, therefore, we may conclude that, in the language of Professor Owen, "the spermatic force" is diffused throughout their entire substance, and not, as it were, concentrated in a particular organ or nucleus.

The question respecting the nature of the many-chambered *Foraminifera*, whether they are to be considered single individuals or colonies of animals, is elaborately examined by Schultze, who comes to the conclusion that the inhabitant of each shell is a single animal. Ehrenberg is the supporter of the opposite view; but Schultze shows that several structural details given by him, upon which the colony-theory is partly established, are erroneous, and that it is one common connected substance which occupies each and every chamber. Prof. Williamson (*T. M. S.* 1851) has the following pertinent observation on this colony-theory. Speaking of the *Orbiculina adunca*, he says—"The attempt to isolate the various portions, and to raise each portion to the rank of an individual animal, even in the limited sense in which we should admit such a distinction in the polypes of a *Sertularia* or of a *Gorgonia*, appears to me wholly inadmissible." Moreover, the soft-structures being devoid of visible organization, "the whole animal will be very little raised above the Polypifera, only possessing a symmetrical calcareous skeleton, which is at once both external and internal" (*i. e.* the Porifera).

Of the Affinities of Rhizopoda.—That the Rhizopoda constitute a class of animalcules distinct from every other is evidenced by their characteristic vital structure and phenomena, their power of producing their like, their growth, their faculty of digesting and appropriating nutrient matters, and by the ascending stages of development seen among them, advancing from the simple *Amœba* to the compound testaceous *Cristellaria* and *Polystomella*.

In the nature of their animal portion they resemble Ciliated Protozoa; it contains similar vacuolæ and granules, and also a contractile vesicle. On the other hand, they differ from them in having no definite outline to the animal tissue bounded by a limiting membrane or integument, and particularly in possessing no cilia, which, as locomotive organs, are replaced by the peculiar and characteristic pseudopodes. In variability of outline an approach is made to Rhizopoda by some genera of the heterogeneous family, *Enchelia* of Ehrenberg; but they never exhibit any such changeable character as the surface of the former, never protrude similar variable processes, nor present a circulation of granules. The *Dinobryina* might perhaps be cited as affording an example of a considerable variability of form; but our knowledge of this family is too incomplete to render analogies based on it of value.

The affinity between Rhizopoda and Phytozoa is no closer. Some of the latter can greatly modify their form in moving; but in none does this partake of the character and extent of the variability exhibited by Rhizopods. Moreover in none are variable processes found, but in general one or more elongated cilia or filaments, which, by their undulation, serve as the principal organs of locomotion.

Between the Testaceous Rhizopoda and Ciliated Protozoa the alliance is even less evident; for in none of the latter do we meet with shells like those of the former, and in none is the relation between a lorica and its contents correspondent to that of the shell and sarcode substance of Rhizopoda. It has already been noted that the distinction between the two classes of Protozoa founded on the silicious character of the shells or loricæ of the Ciliated, and the calcareous nature of those of the Pseudopodous class, is not in accordance with fact; for although all, or almost all, *Polythalamia* have calcareous shells, yet the flexible loricæ of many *Monothalamia* are chitinous, just as those of loricated Ciliata.

In the presumed fact of the shells of *Arcellina* being silicious, Ehrenberg discovered a relation between that family and the Bacillaria. This affinity he traced still further; for, when describing the genus *Cyphidium*, he remarked —"It forms a connecting group between *Arcella* and *Bacillaria*, by reason of the simple locomotive organ (like a snail's foot), and approaches very closely to the group *Desmidieæ*." However, even if he be right as to the single undivided process of *Cyphidium*, the presence of any extended foot or pedal organ from the silicious fronds of Bacillaria, whether *Diatomeæ* or *Desmidieæ*, is not now admitted by any naturalist.

If Stein's observations and opinions be correct, an indirect relationship actually exists between Ciliated Protozoa and Rhizopoda; for that painstaking observer has convinced himself that the *Vorticellina*, by ulterior development, become transformed into *Acineta*-like or Actinophryean organisms, of the intimate affinity of which no doubt can be raised. The questions raised by this apparent transformation do not require discussion here, since they are fully entered upon in the history of the Ciliata, and in that of the *Acinetina*, considered as a subclass of Rhizopoda.

Another alliance was formerly assigned to the Multilocular Rhizopoda, viz. with the Cephalapoda, of which they were treated as a subdivision. This association was suggested, by the *Nautilus*-like form of some genera, to the earliest observers of the *Foraminifera*—Beccarius in 1731, and Plancus in 1739; and the error was perpetuated by D'Orbigny in 1826. Dujardin has the great merit of first combating this mistaken opinion, and of pointing out the extremely simple nature of their contents, and their true affinity with the simple *Amœbæ*.

Several naturalists, and among them M. de Quatrefages, have classed the comparatively large *Noctilucæ* with the Rhizopoda. But direct observation seems to show that, although in a few particulars a likeness obtains, yet the sum of the differences greatly surpasses that of the resemblances. The *Noctilucæ* show a more complex organization; they have an integument composed of two layers, an evident mouth and gastric cavity with appendages, and motile filaments, but no variable processes.

A striking general resemblance subsists between the Naked Rhizopoda—*Amœbæ*—and the like isolated individuals and the germs of freshwater Sponges or *Spongillæ*, which Mr. Carter has named Proteans (XXI. 5 *a*, *b*, *c*). The resemblances are well conveyed in the following quotation from Mr. Carter's paper:—"A ragged portion torn off with a needle, will be seen gradually to assume a spheroidal form; and if there be a spiculum, it will embrace it within its substance, it may even be seen to approach it, and it may bear away the spiculum, having, as it were, spit itself upon it. On its circumference will be observed little papillæ, which gradually vary their form, extending and retracting themselves, until one of them may be seen to detach itself from the parent mass and go off to another object. This little animal, one of the group which it has left, may remain stationary on the second object, or descend to the watch-glass, assuming in its progress all forms that can be imagined, spheroidal or polygonal, whilst every point of its body appears capable of extending itself into a tubular attenuated prolongation . . . . These transparent little sacs (the gemmules of Grant and Hogg) are sometimes filled with green matter. They appear to be able to adapt themselves to any form that may be convenient for them to assume; and when forcibly separated from each other (by tearing to pieces a minute portion of the sponge under water in a watch-glass), the isolated individuals may be seen to approach each other, and apply themselves together in twos and threes, &c. and so on, until, from a particle only discernible by the microscope, they assume the form of an aggregate mass visible to the naked eye; and such a portion, growing and multiplying, might ultimately reach the size of the largest masses adhering to the sides of the tanks at Bombay. They appear to belong to the genus *Amœba* of Ehrenberg."

These changeable globules Mr. Carter, in the subsequent part of his paper, designates Proteans, and states that they commonly resemble the *Proteus diffluens* (Müller). ("Notes of the species, &c. of the Fresh-water Sponges of Bombay," *Trans. Med. and Phys. Society, Bombay*, 1847. Appendix.)

In his more recent contribution on the freshwater Sponges, Mr. Carter describes cells, capable of greatly and rapidly changing their form, endowed with considerable motile powers, and furnished each with an undulating locomotive filament (XXI. 5). These organisms he considers to be zoosperms, or the spermatozoa of *Spongilla*. Speaking of one, he says—"When its power of progression and motion (of a serpentine creeping character) begins to fail, and if separated from other fragments, it soon becomes stationary, and, after a little polymorphism, assumes its natural passive form, which is that of a spherical cell. During this time the motions of the tail become more and more languid, and at length cease altogether." On the other hand, it may attach itself to some fragment, or to another cell, and "become indistinguishable from the common mass; and the tail, floating and undulating outwards, is all that remains visible." In these structures there is, therefore, polymorphism as in Rhizopoda, but no actual extrusion of pseudopodes; and the points of agreement, after all, are really accidental, and not demonstrative of a structural affinity. In them we have reproductive germs, which coalesce and disappear as independent existences, whilst in the case of *Amœba* each specimen is an independent individual, and is never seen to coalesce with others into a common or sponge-like mass.

Dujardin devoted a couple of pages to speak of this affinity between *Amœbæ* and Sponges; and Perty even goes so far as to make the latter a third class of the Rhizopoda, intermediate between *Arcellina* and *Amœbina*, on account of the calcareous, silicious, or horny spicula which occur in their compound mass, and constitute a sort of skeleton.

The affinity with Sponges is traceable even in the case of the testaceous *Polythalamia*, as Prof. Williamson pointed out in 1848, and in a subsequent memoir in 1851 (*Trans. Mic. Soc.*) thus enters on the question:—"Looking at the structure of the shell of the *Orbiculina adunca*, and especially at the large orifices which communicate between its various cavities, we cannot fail to observe that it is a reticulated calcareous skeleton, whose proportionate relation to the size of the soft animal has differed but little from that of the siliceo-keratose network of many Sponges to the slimy substance with which they are invested."

So Dr. Carpenter (*Proc. Roy. Soc.* 1855), in his critical examination of *Orbitolites*, "places that genus among the lowest forms of *Foraminifera*, and considers that it approximates closely to Sponges, some of which have skeletons not very unlike the calcareous network which intervenes between its fleshy segments." With respect to this idea of Dr. Carpenter, that they are allied to Sponges, Mr. Jeffreys (same journal) would remark "that *Polystomella crispa* has its periphery set round at each segment with silicious spicula, like the rowels of a spur. But as there is only one terminal cell, which is connected with all the others in the interior by one or more openings for the pseudopodes, the analogy is not complete, this being a solitary, and the Sponge a compound or aggregate, animal." In a previous page the theory of Ehrenberg, that the *Foraminifera* are compound or aggregate animals, has been referred to. It was on this hypothesis that he assumed their affinity with Polypes—with Flustræ and Bryozoa, at the head of which he arranged them. This association, like the hypothesis it rests upon, is untenable. In his work on the *Foraminifera* of the Vienna basin, M. D'Orbigny assigned a position to these animals as an independent class between Echinoderms and Polypes, which, from the present knowledge of the structure and reproduction of those classes, we cannot suppose he would seek to maintain.

CLASSIFICATION OF RHIZOPODA.—The first division of Rhizopoda that suggests itself is into naked and testaceous forms, or, as Ehrenberg would say, into illoricated and loricated. The naked forms constitute the family *Amœbina*, represented by the single genus *Amœba*.

The determination of specific characters in this family is attended by almost insurmountable difficulties, and can only be unsatisfactory, by reason of the absence of any definite figure, and of determinate organs or parts. Moreover the semifluid body of any one presumed species must be much influenced by external causes, and in some measure by the matters which may have entered into its substance; and the like causes will doubtless operate by modifying the outline, dimensions, and number of the processes. Among such causes the density of the liquid in which they live, and the quantity of organic matter contained in it, may be particularly mentioned. Claparède remarks—"It appears almost absurd to attempt the distinction of species amongst the *Amœbæ* until we know something more of their intimate organization. Thus Ehrenberg's *A. radiosa* is characterized by the regularity of its processes, and its generally stellate form when at rest; but when the creature creeps, it slowly expands and the peculiar outline disappears; it *flows* along like a cloudy veil or drop of oil, and *A. radiosa* has become converted into *A. diffluens.*" Yet, this author afterwards goes on to say—"even the changeable *Amœbæ* have their typical forms, such as the stellate and globular." Other grounds of specific distinction (of no very certain value, indeed) are found in the shape, length, and mode of termination of the variable processes, and in the size, colour, transparency, activity, and habitats of these beings.

The Testaceous Rhizopoda naturally fall into two groups,—one distinguished by having a unilocular, the other a multilocular, shell—the former called, by Schultze, *Monothalamia*, the latter, *Polythalamia* or *Foraminifera.* These grand divisions have been recognized by every naturalist; but some have been led, from giving importance to other particulars, to arrange differently certain genera, or, otherwise, to detach some as additional families.

Thus Ehrenberg, swayed by his polygastric hypothesis, and satisfied in his own mind that the *Arcellæ, Difflugiæ*, and one or two other monolocular genera possessed a series of stomachs and other organs like other Polygastria, united those genera into a family which he called *Arcellina.* This detachment of one group of pseudopodous beings from the rest, he further justified, as heretofore stated, by representing it to have silicious instead of calcareous shells. In this dislocation of evidently-allied forms he finds no imitators, and is unsupported by facts.

D'Orbigny distinguished the one-chambered, sac-like, shelled Rhizopoda as one of the six orders into which he separated the Foraminifera, and named it *Monostegia.* This order is nearly equivalent to that framed by Ehrenberg, under the title of Monosomatia, to comprehend the genera *Gromia, Orbulina*, and *Ovulina*,—a term subsequently borrowed by Siebold, but extended by him so as to include not only the particular genera enumerated, but also the families *Amœbæ* and *Arcellina* of that naturalist.

The term *Monothalamia* contrasts well with that of *Polythalamia*, expresses the fact, and involves no hypothesis as do Ehrenberg's words *Monosomatia* and *Polysomatia*, which are founded on his belief in the colony-like aggregation of several individuals within a Foraminiferous shell.

The *Monothalamia* of Schultze (as before remarked) do not precisely correspond with the one-celled group of either of the other authors named; for, besides the *Monostegia* of D'Orbigny, it comprehends the *Arcellina* of Ehrenberg and a few other new genera. The groupings and relations of the several species are represented in the appended table exhibiting Schultze's system.

In the classification of the *Monothalamia* certain and constant characters are deducible from the shells, whilst those drawn from the soft parts, from the length or tenuity or mode of termination of the pseudopodes, are of comparatively secondary importance, and not to be relied on alone. Definite characters are derivable from the figure, size, composition, sculpturing or appendages, and colour of the entire shell, from the presence of a single large aperture or of many small pores, and from the form of the aperture and of its margin; consequently it is in the shells of the *Polythalamia* that we must seek generic and specific distinctions. As animals, they have all alike the same sarcode substance, which extrudes similar variable fibres: hence any diversities observed in its colour or transparency, in its contents, or in the manner in which the processes are extruded or otherwise comport themselves, serve but a subordinate purpose in the scheme of classification. On the contrary, the characters of the shells are, within certain limits, determinate and fixed. They are derivable from the figure, size, colour, and consistence of the shell; from the markings, processes, pores, and slits occupying its surface; from the relative position and figure of the several chambers; from the mode and degree of their connexion; and from the presence or absence of large apertures in company with the usual foramina; and last, not least, from the intimate structure of the shell. Dujardin recognized the value of the shells to supply the basis of a classification of the Rhizopoda; but he had recourse to the form of the variable expansions to make his primary division, "although," as he remarks, "it has no absolute value." He arranged all the Rhizopoda, with the exception of the *Amœbæ* (which he treats as a distinct family), into two sections,—one having a single unilocular shell with a single large aperture; the other a foraminiferous compound shell, or one having several aggregated chambers, each with a simple orifice, as represented by the tribe *Miliola*. It is in the subdivision of these sections that he employs characters derived from the variable processes. Thus he separates the first into—1. those animals provided with short and thick processes rounded at the extremities, viz. *Difflugia* and *Arcella*; and 2. into those having filiform expansions, acutely drawn out at the ends. The latter division is more largely represented; and he separates its numerous species into three tribes, viz. *Trinema*, with a lateral orifice; *Euglypha*, with a tuberculated or areolated shell and few simple expansions; and *Gromia*, with a membranous spheroidal shell and expansions, thick at the base, but very long and branching. He has not attempted the classification of the whole of the *Foraminifera*, but restricted his account to some few genera which he has found in a living condition.

D'Orbigny instituted five orders of the *Polythalamia*, viz.—1. *Stichostegia*, having the cells arranged one above another in a straight or slightly-curved line; 2. *Helicostegia*, with cells disposed spirally around an axis; 3. *Entomostegia*, having the chambers alternating and coiled spirally; 4. *Enallostegia*, with alternating but not spirally-disposed chambers; 5. *Agathistegia*, having the cells spirally arranged, but each one occupying only one-half the circuit.

The three sections proposed by Schultze are—1. shells disposed in rectilinear series or in a slightly-curved line, *Rhabdoidea*; 2. those coiled in a spiral, *Helicoidea*; 3. those irregularly aggregated, *Soroidea*. The first of these corresponds to the *Stichostegia* of D'Orbigny; the second includes all the remaining orders of that writer; whilst the third section is represented by a small number of species, previously unmentioned, which Schultze unites in the genus *Acervulina*.

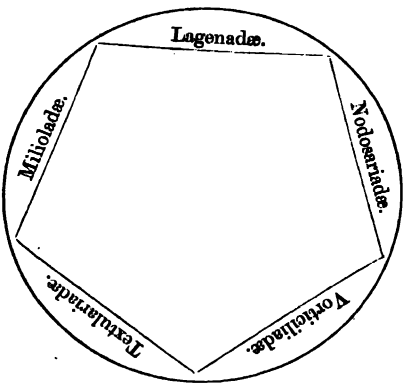
What structural peculiarities should be employed to determine species, is a question now much mooted with respect to the *Foraminifera*. In reference to this subject, Dr. Carpenter (in the annual address at the Microscopic Society, Feb. 1855) observed "that a large proportion of the species, and even of the genera, which have been distinguished by systematists, and especially by M. D'Orbigny, have no real existence, being nothing else than individual varieties." This error is at once accounted for by M. D'Orbigny's mode of proceeding (as stated): "for that, in examining any new collection, he set an assistant to pick out the *most divergent* forms, and then described all that might prove new to him as distinct species, without troubling himself in the least about those connecting links, the existence of which should have at once convinced him that he was following an altogether wrong method. Throughout the whole of his labours on the group, in fact, I find the influence of the erroneous ideas which he originally entertained with regard to the nature of the animal of the *Foraminifera*; for in the formation of his orders, as well as of his genera and species, he has proceeded as if the characters of the testaceous skeleton were of the same distinctive value when its construction is due merely to the solidification of the surface of a minute fragment of animal jelly, which is subject to an almost indefinite variation both in size and in shape, as when it belongs to a mollusk of high organization, the plan of whose conformation is definitely fixed.... When a collection is brought together containing large numbers of individuals of one generic type, which appear, however, to belong to several distinct species, it very commonly happens that, although it would be easy to make 6, 8, 12, or 20 species by selecting the most divergent forms, yet, when the attempt is made to sort the entire collection under these types, only a part of it can be unhesitatingly arranged around them as centres, the remainder being transitional or intermediate forms, for which another set of species must be made, if the principle of separation be once adopted. In fact, to such an extent does individual variation often go, that (as in the case of the human race) no two specimens are precisely alike, and there is no satisfactory medium between grouping them all as varieties of *one species*, and making *every individual a species*, which is manifestly absurd."

The error of D'Orbigny has not escaped Schultze's notice; for in his chapter on classification he has repeatedly pointed out the insufficiency of the characters on which that observer relied in framing his species, genera, and families. For instance (p. 52), he points out the erroneous separation of the *Stichostegia* (D'Orb.) into two families, according to the equilateral or inequilateral condition of the shell. And further on, he remarks that the variations elevated by D'Orbigny to the rank of specific distinctions are merely accidental diversities in growth, connected together by every intermediate variety. Hence, for example, he combines the genera *Triloculina* and *Quinqueloculina* (D'Orb.) into one genus *Miliola*, and the *Orbitoides* and *Orbitulina* (D'Orb.) into a single genus *Orbitolites*. Various other illustrations might be adduced, for instance, the family *Nautiloidæ*; but it is unnecessary to multiply them. It is only fair, however, to state that D'Orbigny is not alone guilty of unduly manufacturing species, but that Ehrenberg, Reuss, and others are equally involved in the fault, which, by the way, is one almost inseparable, and therefore very excusable, in the case of the first observers and systematists of any newly-discovered group of organic beings.

Mr. Jeffreys (*Proc. Roy. Soc.* 1855) deplores the multiplication of species and genera in the present day, and observes that "the *Foraminifera* exhibit a great tendency to variation of form, some of the combinations (especially in the case of *Marginulina*) being as complicated and various as a Chinese puzzle. It is, I believe, undeniable, that the variability of form is in an inverse ratio to the development of animals in the scale of Nature......I am induced to suggest the following arrangement:—

"1. *Lagena* and *Entosolenia*.
"2. *Nodosaria* and *Marginulina*, &c.
"3. *Vorticialis*, *Rotalia*, *Lobatula*, and *Globigerina*, &c.
"4. *Textularia*, *Uvigerina*, &c.
"5. *Miliola*, *Biloculina*, &c.

"This division must, however, be modified by a more extended and cosmopolitan view of the subject, as I only profess to treat of British species. To illustrate McLeay's theory of a quinary and circular arrangement, the case may be put thus:—



"The first family is connected by the typical genus *Lagena* with the second, and by the *Entosolenia* with the fifth; the second is united with the third through *Marginulina*; the third with the fourth through *Globigerina*; and the fourth with the last through *Uvigerina*."

We append a tabular view of the groupings into families and genera, as proposed by Prof. Schultze, since it presents the most complete system yet produced, and advances much nearer a true arrangement of the *Foraminifera* than that made by M. D'Orbigny.

RHIZOPODA.

A. NUDA.

Gen. Amœba (Noctiluca?).

B. TESTACEA.

I. MONOTHALAMIA.

Testa or shell one-chambered; animal undivided, having the same conformation as the shell.

Fam. 1. LAGYNIDA.—A sacciform, calcareous or membranous, non-porous testa, with a large opening.

Gen. Arcella, Difflugia, Trinema, Euglypha, Gromia, Lagynis, Ovulina, Fissurina, Squamulina.

Fam. 2. ORBULINIDA.—A globose, calcareous testa, finely porous throughout, without a large opening.

Gen. Orbulina.

Fam. 3. CORNUSPIRIDA.—A calcareous shell, convoluted like that of a Planorbis, with a large opening.

Gen. Cornuspira.

II. POLYTHALAMIA.

Shell polythalamous; the animal composed of segments, connected by commissural bands.

1. Group HELICOIDEA.

The chambers disposed in a spiral.

Fam. 4. MILIOLIDA.—Each chamber occupies a half-spiral, which is developed either in one plane or in various planes. The shell has only one large opening at the extremity of the last spiral, and no pores.

Gen. Uniloculina, Biloculina, Miliola, Spiroloculina, Articulina, Sphaeroidina, Adelosina, Fabularia.

Fam. 5. TURBINOIDA.—The chambers so disposed spirally as to resemble the shell of Helix or Turbo. The spiral is only visible on one side of the shell. Some are so much elongated that the chambers are, as it were, disposed alternately in two contiguous rows. The shell has a large opening in the last chamber, and its surface is almost always finely perforated.

Subfam. 1. *Rotalida.*—Shell flattened or conical; chambers do not encircle each other; shell glass-like, transparent; finely perforated.

Gen. Rotalia, Rosalina, Truncatulina, Anomalina, Planorbulina, Asterigerina, Calcarina, Siphonina, Planulina, Colpopleura, Porospira, Aspidospira.

Subfam. 2. *Uvellida.*—Shell in the form of a longer or shorter cluster like a bunch of grapes. The chambers frequently appear to almost completely embrace one another. Shell usually thick and coarsely perforate, or solid.

Gen. Globigerina, Bulimina, Uvigerina, Guttulina, Candeina, Globulina, Chrysalidina, Pyrulina, Clavulina, Polymorphina, Dimorphina, Verneuillina, Chilostomella, Allomorphina, Rhynchospira, Strophoconus, Grammobotrys.

Subfam. 3. *Textilarida.*—Spire so much produced that the chambers form a double row and alternate.

Gen. Gaudryna, Textilaria, Virgulina, Vulvulina, Sagrina, Bigenerina, Bolivina, Gemmulina, Cuneolina, Clidostomum, Proroporus.

Subfam. 4. *Cassidulinida.*—Textilaridæ curved once in a direction perpendicular to the original spiral.

Gen. Ehrenbergina, Cassidulina.

Fam. 6. NAUTILOIDA.—The chambers so disposed spirally that the shell has a general resemblance to that of an Ammonite or Nautilus. The spire is either visible or, otherwise, concealed on both sides of the shell. The anterior wall of the last chamber is furnished with one larger or several smaller openings; the other portion of the shell is usually finely perforated.

Subfam. 1. *Cristellarida.*—Shell thick, finely perforate, colourless, transparent; chambers encircling, with a large opening at the upper angle of the anterior wall of the last chamber, which corresponds in position with the communicating openings between the several chambers.

Gen. Cristellaria, Robulina, Marginulina, Flabellina.

Subfam. 2. *Nonionida.*—Shell thick or thin, colourless, transparent, finely perforate; chambers either encircling (imbricate) or not. The opening is in the anterior wall of the first chamber on the under side looking towards the penultimate spiral; the communicating openings of the several chambers have a similar position.

Gen. Nonionina, Hauerina, Orbignyna, Fusulina, Nummulina, Assilina, Sidorolina, Amphistegina. Operculina and Heterostegina should probably be formed into a special subfamily of Nonionida.

Subfam. 3. *Peneroplida.*—Shells usually thin, always brown, and transparent with or without fine pores; the chambers very narrow, either imbricate or not. Numerous openings, scattered over the whole of the anterior wall of the last chamber; or, instead of these, a large opening produced by the coalescence of numerous smaller ones.

Gen. Peneroplis, Dendritina, Vertebralina, Coscinospira, Spirolina, Lituola. *Appended genus,* Orbiculina.

Subfam. 4. *Polystomellida.*—Shell tolerably thick, colourless, transparent, finely porous; chambers imbricated; the anterior wall of the last chamber has, besides the fine pores, either no larger opening at all, or a few very small irregular scattered fissures, on the contrary side to the penultimate whorl. The same applies to the septa. On the surface of all the chambers, rows of fissure-like, often perforating, depressions are placed at right angles to the direction of the septum.

Gen. Polystomella.

Fam. 7. Alveolinida.—Globose, ovoid, or barley-shaped shells, composed of spiral tubes, each resembling a cornuspira, and furnished with a special opening at the end of the turn or spiral. The tubes all communicate by connecting openings, and, besides this, are all subdivided by incomplete dissepiments (partitions), in the same manner as species of Nonionina. The situation of these septa, which are but few in number, and of the connecting openings, is indicated by lines, which traverse the shell in the direction of meridional lines.

Gen. Alveolina.

Fam. 8. Soritida.—Discoid, multicellular shells, exhibiting an indication of a helicoid spiral only in the centre; elsewhere cycloid, that is, growing uniformly at the whole border of the disk. The brown, transparent, finely porous shell is formed of minute chambers, connected together in the direction of straight or curved radii, and each presenting a large opening at the border of the disk.

Gen. Sorites, Amphisorus, Orbitulites. *Appended genus,* Cyclolina (chambers perfectly annular, with numerous openings on the border of the disk).

2. Group Rhabdoidea.

The chambers piled one on another, in a straight or slightly curved line, in a single row.

Fam. 9. Nodosarida.—Rod-shaped shells, whose chambers are superimposed one upon another in a row, and communicate with each other by a large opening; a similar opening in the last chamber (except in the genus *Conulina*, which has numerous openings instead of the single one). The shell usually thick, probably always perforated by fine pore-canals.

Gen. Glandulina, Nodosaria, Orthocerina, Dentalina, Frondicularia, Lingulina, Rimulina, Vaginulina, Webbina, Conulina.

3. Group Soroidea.

Chambers grouped in irregular masses.

Fam. 10. Acervulinida.—Chambers usually globose, disposed very irregularly, and of pretty uniform dimensions; shell finely perforate, with a few larger openings at indeterminate places.

Gen. Acervulina.

The preceding account of the Rhizopoda we believe to be ample to lead the student forward in the study of that peculiar class of animals. Yet, with respect to the division *Foraminifera* it may be considered less complete: for, from the close attention given of late to those beings, every monthly and quarterly periodical of natural science teems with fresh facts and opinions concerning them; and, above all, we have had placed in our hands, since the foregoing history was written, the very elaborate and critical researches of

Prof. Williamson and Dr. Carpenter, to which we would particularly refer the inquirer intent on following out his knowledge of the *Foraminifera*, but which both the dimensions and the character of the present work forbid the attempt to condense or analyse in its pages. Prof. Williamson's work, 'On the Recent *Foraminifera* of Great Britain,' forms the volume for 1857, published by the Ray Society. Dr. Carpenter's learned essays on the structure of shells, on the value of form and other external characters in generic and specific groupings, and on the structural and physiological relations of several genera, are to be found in the 'Transactions' and in the 'Proceedings' of the Royal Society.

Additional facts concerning both the structure and relations of the several groups of Rhizopoda will be found in our Systematic History of them in Part II.

SUBFAMILY OF RHIZOPODA, ACTINOPHRYINA.

(Plate XXIII. 24-37.)

This is a remarkable group of Protozoa, which can take its place neither with Ciliata nor strictly with Rhizopoda, although its affinities with the latter are very close. Ehrenberg attached the several forms of this family with which he was acquainted to his heterogeneous collection—the family *Enchelia*, and referred them to five genera, viz. *Actinophrys*, *Trichodiscus*, *Podophrya*, *Dendrosoma*, and *Acineta*. Moreover, according to his fundamental hypothesis, he represented them to have a mouth and an anus, an alimentary canal with offshoots in the shape of stomach-vesicles, a sexual gland, and ova. Since the Berlin professor's investigation of these animalcules was made, several distinguished naturalists have most carefully studied them, and particularly the *Actinophrys Sol*.

In our last edition we named a genus *Alderia*, in honour of Prof. Alder, to distinguish certain organisms described by him in the *Annals of Natural History* (1851, vii. p. 427). Subsequently, however, that eminent naturalist wrote us to state that the name proposed had been already applied to a genus in another class of animals; and on further consideration and reference to Stein's researches, we were inclined to renounce their claim to a generic independence, and to consider them three forms of *Podophrya*. Dr. S. Wright has, however, apparently observed the same beings very lately, and instituted a new genus, *Ephelota*, to receive them (*Edinb. New Phil. Journ.* 1858, p. 6).

Notwithstanding the very close affinities of *Actinophryina* and *Acinetina*, there are sufficient differences between the two, and so many peculiar forms of the latter that they deserve a particular consideration.

The history of the first family is very fairly represented by that of *Actinophrys Sol*, or of *Act. Eichornii*, both of which have been very completely studied by Siebold, Kölliker, Claparède, Stein, and Weston. Some diversity prevails among these several observers respecting a few points in their organization, which it will be incumbent on us to notice in the proper place. The species of *Actinophrys* have a circular figure, and are either spherical or so compressed as to have a discoid form (XXIII. 28, 29). The distinctive peculiarity of their figure is, however, due to the filaments or tentacles, which radiate from all parts of their surface and give the beings (to employ a familiar and not inapt illustration) the appearance of a ball of cotton stuck thickly over with pins; for the filaments have nodular extremities, or, in technical phrase, are capitate. The figure is determinate, and in this respect contrasts with the protean changes of form exhibited by Rhizopoda. Not that the figure is completely unalterable; for slight variations are possible, although slower than even those of *Amœba*. Stein represents the usual orbicular figure to be frequently exchanged for a pear-shaped, an oblong, or a partially angular and lobed one,—varieties dependent, according to his statements, upon inherent changes taking place in connexion with progressive developmental phenomena. The aspect of the entire organism is, moreover, modified from time to time, by the altered length, direction, and disappearance of a portion of the filaments, chiefly consequent on the act of prehension in which they are engaged. Stein, indeed, represents still more considerable modifications, involving the complete disappearance of tentacles from various portions of the surface, and the aggregation of the rest upon angular eminences in a penicillate manner,—an occurrence which would assimilate still more closely the *Actinophryina* and the *Acinetina*. Lastly, the figure is varied during the acts of self-division and of conjugation, as will be presently noticed at large.

In colour the *Actinophryina* are commonly of a milky-yellow or greyish hue, the intensity of which is determined by the number of contained granules, or, in other words, by the supply of nutriment. Acetic acid and cold solution of potash remove colour; the latter fluid, when heated rapidly, dissolves the entire mass, and indicates its nitrogenous nature. Observers are not agreed on the point of the existence of an integment. Dujardin, Kölliker, and Claparède deny it, whilst Stein, Perty, and Mr. Weston (*J. M. S.* 1856) affirm its presence. Among the latter, one speaks of it as a hyaloid membrane; another declares it to be double, consisting of a delicate elastic membrane immediately investing the contractile substance of the animalcules, covered by an outer firmer tunic. This statement is especially made by Stein of *Podophrya*, which is, in his opinion, a merely stalked variety of *Actinophrys*, and indistinguishable from it even as a species (XXIII. 1, 3, 4, 5). On the contrary, Cienkowsky (*J. M. S.* 1857, p. 98) remarks that he could discover no membrane surrounding the body of that animalcule. To account for this diversity in descriptive details, we must suppose that the different authors have not had the same animalcule under observation; indeed Stein asserts that Kölliker did not examine *Actinophrys Sol*, as he supposed, but *Act. Eichornii*. Lieberkuhn likewise suggests that Claparède and Kölliker have written upon different species under the same name; and Stein must, we believe, have committed a similar mistake; for the *Actinophrys* and *Podophrya* described by him differ in so many important particulars from beings bearing the same name in the writings of others, that it seems impossible they can be identical with them. The fact seems to be that certain *Acinetæ* have in external characters so close resemblance to *Actinophryina*, that they may be mistaken for them. Be this how it may, if we take into consideration the peculiar relation of the tentacles with the body, their movements, and especially the mode of introducing food into the interior, it seems quite improbable that there should be a firm investing membrane. These remarks, indeed, apply only to the usual forms or phases of these beings; for when an encysting process proceeds, then, certainly, an external envelope will manifest itself, yet not without the sacrifice of the tentacula and of the ordinary phenomena of vital activity, the ingestion of food and the like. "It is impossible," to quote Claparède (*A. N. H.* 1855, xv. p. 286), "to admit the existence of a general integument, as *Actinophrys* can push out the mucous or gelatinous matter of which its body is composed, take in nourishment, or evacuate the residue of digestion, from any point of its surface at pleasure." In this same observer's opinion, Perty's notice and figures of a capsule are evidently erroneous, the consequence of optical illusion. Mr. Carter adopts an intermediate opinion, by admitting the existence of an enveloping pellicula, like that in *Amœba*, which, although not a separable layer or skin, is a somewhat firmer or more condensed tissue than that subjacent.

The *Actinophryina* are composed of a homogeneous elastic sarcode, occupied by granules in varying number, and by vacuolæ. The granules are especially accumulated in the centre, to which they consequently impart a greater opacity and deeper colour. Hence several authors have spoken of a central medullary mass surrounded by a clearer cortical lamina (XXIII. 28, 29). Still there is no natural separability into two such portions; for their relative size varies according to the supply of food received. Dr. Strethill Wright (in a letter) proposes to apply the unexceptionable terms "*endosarc*" and "*ectosarc*" to the medullary and cortical portions respectively. The contained granules are rounded, opaque, and, for the most part, of a fatty character. The granules are less abundant in the ectosarc; but those of a finer sort are seen in smaller numbers even in the lower end of the filaments, and Lachmann (*A. N. H.* 1857, xix. p. 223) asserts that he has seen their motion there, as well as in the general substance of the body. Mr. Weston also remarks (*op. cit.* p. 122), "With a $\frac{1}{8}$th objective I can distinctly see granules in constant motion in the body of the *Actinophrys*, similar to those always found in the points of *Closterium Lunula.*" The vacuoles occur both in the cortical and medullary portions, but are smaller in the latter, and they never penetrate into the substance of the filaments.

At first sight, as Kölliker notices, the tissue appears delicately cellular: a closer inspection, however, shows that this is not the case; for on pressure being made, a coalescence into larger, or, otherwise, a subdivision into smaller, areolæ is the consequence (XXIII. 28, 29, 30).

The tentacles or filaments give to the *Actinophryina* their most distinctive features. They are usually pretty regularly and uniformly distributed over the entire surface, and in figure taper from the base to the apex, which is surmounted by a rounded knob. Unlike other observers, Cienkowsky (*J. M. S.* 1857, p. 101) represents the capitate form to be exceptional, and that the rule is for the filaments to taper like setæ. Dujardin, by the way, appears to have thought the capitate extremities accidental; for he describes the filaments as often becoming globular in the act of contraction. In smaller specimens the filaments exceed the diameter of the body in the length, but in larger ones are not more than equal to, or are even less than, it. In the same species their number and position are tolerably constant. In composition, the tentacula are processes given off from the sarcode mass, and are destitute of an integument, as proved by their power of coalescence when approximated. They are retractile, and can be withdrawn into the common mass; they can also be directed towards different sides, and curved upon themselves. Perty states that they can assume so rigid a condition that other animalcules sometimes impale themselves upon them; this statement is nevertheless unconfirmed, and, indeed, seems scarcely probable. Kölliker (*op. cit.* p. 31) speaks of the filaments as undergoing various changes of form, "such as elongation, shortening, local swelling, bending, &c.... It is especially interesting to observe that the filaments, singly or together, frequently disappear entirely, entering at last, as it were, by continued retraction, into the substance of the body, leaving no trace of their former existence.... whether the filaments which disappear are always reproduced in the same spot is not determined; in some instances this did not appear to be the case, although in every instance the number and position of the filaments is pretty constant"—unlike the variable processes of *Amœba*. Ehrenberg assigned to the tentacles, among other purposes, that of organs of progression; direct observations are, however, wanting to prove this purpose, and both Kölliker and Stein are quite unable to admit it as even probable. They have been supposed by several authors to have a benumbing effect upon the prey they may seize; but this view is merely hypothetical. "It is nevertheless," says Claparède (*op. cit.* p. 287), "quite certain that small animalcules and plants remain adherent to them; for these rays are true tentacles. Indeed, their contact must have something very unpleasant about it; for larger Infusoria, even such as *Paramecium Aurelia*, on coming accidentally within their reach, start back with the greatest rapidity, sometimes even dragging the *Actinophrys* a considerable distance with them." So, again, Weston states—"on the instant of contact with these tentacles, the victim appears paralysed." Yet, withal, it seems clear that, unless actual contact ensue, no harm attends proximity to the formidable prehensile organs; for animalcules may frequently be seen swimming about unharmed among them. Kölliker rejected the supposition of an intrinsic fatal influence existing in the filaments, which appeared to him to serve only for retaining the prey by their adhesive surface, and probably to involve it with their extremely fine extremities, until they drew it by their progressive contraction to the surface. Even after being seized upon, an animalcule may escape, both by great exertions in tearing itself away, and sometimes, as Mr. Weston remarks, by the act of the *Actinophrys*, when, as it would seem, its appetite was "sated, or the prisoner was not approved; for after remaining stunned sometimes for a few seconds, four or five, sometimes much longer, ciliary motion (of a *Vorticella*, for instance) is feebly commenced, not with sufficient energy to produce motion, but as if a return to vitality were being effected by struggles; shortly it is seen to glide off the tentacle (as if this appendage possessed the power both of appropriation and rejection), and, frequently with but little sign of recovered life, it slowly floats out of the field." One function distinctly possessed by these tentacula is that of sensibility. Kölliker has thus well conveyed this fact (*op. cit.* p. 33): —"*Actinophrys* perceives mechanical influences, and reacts upon them by movements. This is proved by what takes place when animalcules, &c. remain affixed to its tentacles, and moreover by the circumstance that, when the water in which it is contained is carelessly agitated, every *Actinophrys* contracts its tentacles and even makes them disappear altogether (and, indeed, with greater speed than is otherwise perceived in these creatures), and when all is quiet they are again protruded. These filaments, consequently, may just as well be called tactile as prehensile; or it may more generally be said, that the substance of the body is both contractile and sensitive."

MOVEMENTS.—There is not much to be said respecting the movements of the *Actinophryina*; for these beings are even more sluggish than the *Amœba*, and appear to change place rather as mere passive particles of matter than as living animals. They may float hither and thither in the fluid surrounding them, or rise to the surface; but how this latter movement is effected we have no data to show. On this subject Kölliker has the following paragraph:— "Its power of moving from place to place is indubitable; for it was found, for instance, that when a vessel, with several individuals of *Actinophrys*, was emptied into a flat glass capsule, they were all at first scattered about at the bottom, but subsequently, after from 12 to 24 hours, were all floating at the surface, and, indeed, at the side of the capsule. Ehrenberg and Eichhorn assert that the ascension of *Actinophrys* in the water is effected by the taking in, and the descent by the giving out, of air. But this is certainly not the case; for whence could they obtain this air? Can it be said they secrete it within themselves like fishes? In that case it must be visible. It appears to the author more natural that the rising and sinking should be effected by alternate contractions and expansions of the whole body. Other motions can affect both the filaments and the body, but in any case only through the slowest possible contractions." Besides these ill-understood translations from place to place, and those movements chiefly affecting the tentacles in the act of taking in food, to be presently noticed, there also occur, according to Kölliker, "faint indications of contraction, such as slight undulations of the border, and inconsiderable quivering motions here and there. The creature also seems to be capable of altering its entire form to a certain extent, and to be able to expand and to contract itself *in toto*." Stein contradicts these statements, affirming that he could neither observe any movement in the organic mass, nor any change of position, whilst Claparède, on the other hand, writes, "nevertheless the animal, in its ordinary sun-like form, is able to move slowly in a given direction; but during this movement no contraction of the body or bending of the tentacles is to be observed." A singular observation is recorded by Mr. Boswell (*T. M. S.* 1854, p. 25), which needs confirmation before it can be accepted, viz. that the *Actinophryina* can suddenly change their place by a leap. This phenomenon, he tells us, he witnessed twice among a number of the animalcules found floating on the surface of the water. Usually the *Actinophrys* is found attached to some object, and that so firmly that large animalcules may strike against it, or strong succussions of the water take place without loosening it from its hold. *Podophrya* and *Dendrosoma* are exceptional *Actinophryina*, by possessing a pedicle. In the former this stem is commonly short and always simple, whilst in the latter and hitherto little-known genus it is branched. As elsewhere noticed, Stein will not admit the pedicle of *Podophrya* to be a generic, indeed not even a specific, distinction, and therefore treats *Actinophrys* and *Podophrya* as identical. In connexion with his belief in the presence of an enclosing integument, he describes the wall of the hollow pedicle of *Podophrya* to be continuous upwards with the external envelope of the body (XXIII. 3, 4). It is proper, however, to remember that Stein wanted both to establish his hypothesis of the conversion of *Vorticella* into an *Actinophrys* and *Podophrya*, as a consequence of the act of encysting, and preparatory to embryonic reproduction, and, further, to assimilate those genera with various *Acinetæ*, which, in his opinion, were derivable from other members of *Vorticellina*. This detracts from the value of his details of the structure and functions of *Actinophrys*; and, as expressed above, a great doubt suggests itself whether he has always examined the selfsame animalcules, and whether what he has described applies to the *Actinophrys* investigated by Kölliker and Claparède. Cienkowsky, who has latterly tested Stein's hypothesis, asserts, respecting the question of the structure of the stem of *Podophrya*, that the pedicle is an appendage to the body, which has no integument. "I am unable" (*op. cit.* p. 100), he writes, "to adopt Stein's view that the *Podophrya* are enclosed in a membrane, of which the slender pedicle is simply a tubular protrusion. This is true only with respect to the short peduncle of the encysted *Podophrya*" (XXIII. 36, 37).

Prehension and Entrance of Food.—The movements of the tentacula of *Actinophryina* are chiefly directed to the prehension of prey for food. This they effect primarily by seizing it by means of their apparently sticky surface, and then, by shortening themselves, drag it to the surface of the animalcule. If the prey has been caught by one tentacle, the neighbouring ones conspire to clutch it more firmly, and (to use Kölliker's words) "apply themselves upon it, bending their points together, so that the captive becomes gradually enclosed on all sides." This concurrence and crossing of the tentacles is mentioned also by Stein; but Mr. Weston states that he has never witnessed it.

Concerning the mode of entrance of the nutritive matter when drawn to the surface, some difference of opinion prevails among the several writers who have treated of it. Ehrenberg, true to his hypothesis, attributed to *Actinophryina* a mouth surmounted by a proboscis, and an anus at the opposite side with an intercommunicating intestine and numerous stomach-sacs opening into it. In short, they were, according to his scheme of organization, *Enantiotreta*, of the class Enterodela. Dujardin rejected this account, and supposed them to be nourished by absorption, carried on by the general surface, or by means of thick expansions from it. At the present time all observers unite in denying a mouth, anus, and alimentary canal to *Actinophryina*, and in admitting that food may be introduced, and its débris discharged, at any part of the surface,—a fact patent to direct observation, which shows the seizing and the entrance of prey going on, occasionally, at more than one point at a time (XXIII. 29–32). We have followed the captured morsel until it approaches the surface, and when the force of the tentacles behind it still tends to press it onwards into the body. The following proceeding, according to Kölliker (*op. cit.* p. 28), now takes place:—"The spot of the surface, upon which the captured animalcule is lying, slowly retracts and forms at first a shallow depression, gradually becoming deeper and deeper, in which the prey, apparently adherent to the surface and following it in its retraction, is finally lodged (XXIII. 29 *m*). The depression, by the continued retraction of the substance, now becomes deeper; the imprisoned animalcule, which up to this time had projected from the surface of the *Actinophrys*, disappears entirely within it; and at the same time the tentacles, which had remained with their extremities applied to each other, again erect themselves and stretch out as before. Finally, the depression acquires a flask-like form, by the drawing in of its margin, the edges of which coalesce; and thus a cavity closed on all sides is formed, in which the prey is lodged. In this situation it remains for a longer or shorter time, gradually, however, approaching the central or nuclear portion, and at last passing entirely into it in order to await its final destination. In the meanwhile the external portion of the *Actinophrys* regains in all respects its pristine condition. The engulfed portion is gradually digested and dissolved." Whilst admitting the general correctness of this account by Kölliker of the act of inglutition, Stein asserts that, prior to the appearance of the prey in a depression of the body, a large vacuole, rising above the surface, comes into contact with it, and then, by its collapse, drags it downwards into the substance of the animalcule. This stage he supposed Kölliker to have overlooked. However, Claparède denies that the reception of food is ever effected by means of the expansion and contraction of a vesicle, or that, as Kölliker believed, the food penetrates the substance of the body by the force exercised upon it behind by the tentacula: it is rather, he says, the substance of the body which approaches and embraces the food; for before the latter has touched the surface of the body, it is seen to be enveloped in a kind of mucus. "This mucus is completely undistinguishable from the parenchyma of the *Actinophrys*; it appears as though the substance of which it is composed had suddenly drawn itself over the captured object. The elevation thus produced then slowly flattens; and by this means the food is gradually drawn into the body. *Astasiæ*, which I frequently saw sucked in by *Actinophrys* in this way, continued to move for a little time, endeavouring to break through the substance that enveloped them; their movements, however, soon ceased; they became converted into a globular mass, which circulated very slowly through the parenchyma with the so-called vacuola."...."At first I thought the substance, which so suddenly enveloped the object to be swallowed, was produced by the mere bending, expansion, and fission of the tentacles. I could not, however, retain this opinion: an extension of a mucous substance, apparently the parenchyma, really takes place from the side of the *Actinophrys*; and this is afterwards drawn in with the prey. This expansion sometimes takes place very slowly; a thick, regularly lobed mass is seen to embrace the object; and I have once observed this extension without the presence of any prey. I can only compare this process with what takes place in *Amœba*." Dr. Strethill Wright (in lit.) expresses the same fact in a condensed form, thus:—"In *Actinophrys* the tentacles bring the food to the surface of the ectosarc, which closes over it and carries it to the endosarc." Mr. Weston's observations tend to a similar interpretation of the mode of introduction of food. "From the margin of the body of the *Actinophrys*," says this gentleman, "a thin pellucid membrane is projected up the side of the creature destined for food (XXIII. 24–32), which proceeds rapidly, but almost imperceptibly, to surround one side of it; a similar membrane springs sometimes also from the *Actinophrys*, but more frequently from the tentacle on its other side; these amalgamate on the outer surface of the prisoner, which is thus enclosed in a sac composed of what I take to be the extended outer vesicle of the *Actinophrys*. This vesicle gradually contracts, or, rather, seems to return by elasticity to its original position; and the food thus becomes pressed within the body, there to become digested." The conclusion to be drawn is, that, after the act of prehension by the tentacles is complete, the retraction of those processes is succeeded by the protrusion of a sort of variable process, similar to those of *Amœba* in character, and also in its mode of enveloping and engulfing the morsel.

After its admission into the soft substance of the interior, the nutrient matter undergoes a process of digestion, by which, if soft, it suffers complete dissolution and absorption; but if it contain insoluble matter, this remains behind, after the disappearance of the rest, as a residue to be sooner or later cast out through an aperture temporarily formed at the point of the surface it comes into contact with, and of which all trace is lost so soon as the act of extrusion is accomplished. The molecular and granular matters derived from food collect especially in the central or nuclear portion of the body, the depth of colour, opacity, and strength of which are directly proportionate to the supply of food. The particle of food (the animalcule or other substance), when in the interior, is surrounded by or suspended in a drop of fluid, or, in Dujardin's phraseology, occupies a vacuole. This fluid is either drawn in by the act of inglutition, or is a secretion poured out around the food for the purpose of digestion. Claparède takes the latter view, and states that the fluid always exhibits the same pale-reddish colour as the contents of the contractile vesicle, and indicates different refractive powers from those of water. This observation accords with one made by Schneider, of the digestive vacuoles of *Amœba*.

The process of digestion is slow. Claparède observed the changes of a *Chlamydomonas*, and states that three hours scarcely sufficed for its conversion into an unrecognizable gelatinous mass. Kölliker represents the time to vary from two to six hours; but this must differ perpetually according to the nature of the food, the vitality of the animal, &c. "The number, as well as the size," writes Kölliker, "of the morsels taken at one time by the *Actinophrys* is very various. Very frequently there may be 2, 4, or 6 at the same time, frequently also more than 10 or 12. Ehrenberg counted as many as 16 stomachs, *i. e.* in other words, so many separate morsels. He also noticed the ingestion of indigo, which could not have gained admission in any other way than that by which the Infusoria and other aliments enter. The largest morsels noticed consisted of a Lynceus and a young Cyclops. Eichhorn, indeed, mentions a water-flea (*Daphnia* ?), about the size of which, however, no remark is made." Indeed, the *Actinophryina* are rapacious animals, and will appropriate to themselves any organisms, vegetable or animal, which fall in their way. Thus, besides those beings alluded to already, Rotifera, various minute Crustacea, Ciliated Protozoa, Phytozoa of all sorts, Desmïdiceæ, Diatomeæ, minute Algæ, and their spores alike fall a prey to these remarkable animalcules. The excrementitious particles of food, as already stated, pass out at any spot where circumstances may direct them; and no definite anal aperture, such as Ehrenberg imagined, has an existence. The expulsion of residual matters, Mr. Weston (*J. M. S.* 1856, p. 121) states he has "frequently seen,—in one specimen twice in less than half an hour, at different spots. In watching the digestion of a Rotifer, it occurred to me to see a dark body, composed apparently of the case, remain for some hours in the same spot, and then gradually approach the side, as if for expulsion; but while waiting for this to take place, an opening in another part occurred, and excrement was voided in quantity: this voided matter lies amongst the bases of the tentacles, while the opening through which it has passed closes; and then, with the same stealthy motion I have before described, it is apparently driven along the tentacles (as if by repulsion) beyond their extremities, finally disappearing in the surrounding medium."

CONTRACTILE VESICLE.—The rule is, that only one contractile vesicle belongs to each animalcule (XXIII. 36, 37). If more appear, it usually indicates either the approach of fission, or the conjugation of two or more individuals (XXIII. 33–35). Kölliker failed to recognize this organ in *Actinophrys*, and concluded that Siebold had described as such the more changeable vacuola. However, Stein, Claparède, Cienkowsky, and others concur in representing a contractile vesicle as normally present; the first-named writer, indeed, describes in a few instances two such, as Siebold has done before him. Stein exhibits, in *Actinophrys Sol*, the vesicle as central (XXIII. 1); but other naturalists concur in representing it as superficial,—so much so, according to Siebold, that it will frequently during its expansion project above the general surface, and thereby prove itself to have a distinct wall (XXIII. 29 *m*); for if composed of only the gelatinous parenchyma of the body, it would burst at the moment of greatest expansion. It is, therefore, a closed sac or cell. Claparède has never found more than one vesicle, and thinks both Siebold and Stein in error in describing two. "Several vesicular elevations," he writes, "often occur on the margin; but only one of these is contractile. I have, however, observed two contractile vesicles in several individuals; but in these cases the form always gives rise to a suspicion of fission, or of an amalgamation of two individuals (*Act. difformis*, Ehr.). The presence of a single contractile vesicle does not, however, appear to be universal among the Rhizopoda; I have observed two in *Arcella vulgaris*. . . . It is surprising that Kölliker, who was acquainted with Siebold's observations, should have characterized them as inexact, and as arising from an illusion. According to him, Siebold had mistaken accidental expansions and contractions of the substance enclosing the vacuoles, in which the latter were persistent, for phenomena indicating the existence of contractile reservoirs. This, however, is not the case; the size, the unchanging position, and the regular expansion and contraction of this organ will prevent its being confounded with a vacuole. That Kölliker should have overlooked it is particularly unintelligible, as the phenomenon is immediately presented by nine out of ten specimens of *Actinophrys*."

Carter (*A. N. H.* xviii. p. 129) makes the curious assertion, that the "*Actino-*

phrys Sol, Ehr., is surrounded by a peripheral layer of vesicles" (he is speaking of contractile vesicles), "which, when fully dilated, appear to be all of the same size, to have the power of communicating with each other, and each, individually, to contract and discharge its contents externally, as occasion may require, though generally only one appears, and disappears, in the same place." Stein describes and figures a row of vesicles immediately beneath the surface of a new species he calls *Actinophrys oculata* (XXIII. 24, 25), but does not, like Carter, treat them as so many contractile sacs, an interpretation which cannot be received without much more extended inquiry and confirmation. Notwithstanding this assertion, Mr. Carter, in his outline of facts relevant to contractile vesicles in general, has the following clause, applying specially to the animalcules under consideration, and giving a most apt illustration of the phenomena witnessed:—"In *Actinophrys Sol*, and other *Amœbæ*, during the act of dilatation, the vesicula projects far above the level of the pellicula, even so much so as occasionally to form an elongated, transparent, mammilliform eminence, which, at the moment of contraction, subsides precisely like a blister of some soft tenacious substance that has just been pricked with a pin." At another part, this same author says, generally (*op. cit.* p. 128), and in some measure contradictorily to the first statement quoted from him, that "in *Amœba* and *Actinophrys* the vesicula is generally single; sometimes there are two, and not unfrequently in larger *Amœbæa* a greater nnmber." It should be mentioned that Stein found in the animalcule, which he took to be *Act. Eichornii*, a superficial group of vacuola, rendering the outline irregular,—a phenomenon no doubt the same as that intended by Carter. Stein, moreover, described in the same animalcule two contractile spaces, one at each pole, immediately beneath the surface, but capable of alternately elevating themselves above, and depressing themselves within it, and of thereby aiding to introduce food.

Podophrya has, according to Stein and Cienkowsky (XXIII. 34, 35, 36, 37), a single circular contractile vesicle. Stein, indeed, figures two in one specimen. So far as appears, the vesicle is not placed so close to the surface as in *Actinophrys*. Among other structures mentioned by Ehrenberg, was a contractile proboscis, by means of which the animalcule was supposed to receive food; but other observers have looked in vain for any process to which such an appellation could with justice be applied. The structure intended by Ehrenberg is, in Claparède's opinion, no other than the contractile vesicle, —an opinion in which Mr. Weston seems to agree (see below), although he attributes to it a structure and action without parallel in other Infusoria. A glance at the quotation above made from Mr. Carter's paper will show also that the contractile sac was intended. The following are the observations of Claparède, referring to the matter in question:—"From time to time a globular prominence rises slowly and gradually from a particular point on the surface of the animal; this increases more or less in different cases, sometimes, especially in small individuals, attaining nearly a third of the size of the entire body, but generally reaching only $\frac{1}{8}$th or $\frac{1}{10}$th of that size. The margin of this projection is always well defined, much more so than the other parts of the body, especially when it has attained its greatest evolution. At this moment it contracts suddenly and disappears entirely, so that a flattening of the outline is often to be observed at the point previously occupied by this remarkable elevation: the margin soon becomes rounded again; the globular projection gradually rises, attains its previous highest development, and then suddenly disappears again." The following paragraph from Mr. Weston's paper (*J. M. S.* 1856, p. 116) refers, doubtless, to the selfsame expanding and contracting process distinguished by Claparède; but the function of respiration and a valvular structure of a very extraordinary nature are attributed to it. We suspect, indeed, that Mr. Weston has been led into error by appearances, —a supposition he will pardon us for making, since, as he himself tells us, his microscopic experience is less than two years old. His account runs thus:— "There appears to be no doubt about the existence of a valvular opening: I have had some thousands of these animalcules under my observation, and have never met with a specimen where the valve was absent. It is best distinguished when about the edge of the *seeming disc*, and, so far as my observations go, is never still night nor day,—being slowly, but without cessation, as it were, protruded, occupying from 10 to 70 or 80 seconds in its development, and then, like the bursting of a vesicle, rapidly and totally subsiding; for an instant it has utterly disappeared, only to be again as gradually and as certainly reproduced. Should that side of the creature, where the valve is placed, be turned from the observer, *the effects* of the contraction are distinctly seen, although the valve itself is not; for at the instant of its bursting and closure, some half-a-dozen or more of the tentacles, *situated on or about it*, which have been gradually thrust from their normal position by the act of its protrusion, now rapidly approach each other with a jerk-like motion, caused by the sudden bringing together of their bases.

"With $\frac{1}{8}$th of an inch objective, I have been led to imagine the valve to be formed of a double layer of the external hyaloid membrane, the edges of which appear to adhere to each other tenaciously, notwithstanding the growing distension from within, until the force becomes so great that the lips, as they may be called, suddenly separate, apparently to give vent to some gaseous product; and at this moment there is, as I have stated, enough seen to induce the belief in the existence of a double lip-like valve, *perhaps the organ of respiration.*"

He afterwards adds (p. 118)—"In many instances I have seen half-a-dozen or more prisoners attracted to the tentacles of an individual, each gradually absorbed; and although thus busily occupied, no cessation of the action of the valve takes place." Stein imagined the movements of the contractile sac to be subservient to the reception of food; but this supposition, as mentioned already (p. 248), is opposed to analogy, and is wanting in direct observation to establish it.

Among the general contents of the body of *Actinophrys*, Kölliker (*op. cit.* p. 27) mentions some separable nuclear cells as detached by crushing from the innermost portions of the animal. When isolated by pressure, they behave themselves as cells, with nucleus and nucleolus, sometimes as free nuclei. "The author is, in fact, inclined to regard them as cells and nuclei, lying in some of the interior vacuoles; for such, and such only, are the vesicular spaces in which they are enclosed." (XXIII. 29.)

Nucleus.—Kölliker applied the term nucleus, very improperly, to the more granular and darker central or medullary portion of the body (XXIII. 29 *h*), and overlooked the presence of the real nucleus. However, Stein, Carter, Cienkowsky, and others have determined the existence of this organ in the genera *Actinophrys* and *Podophrya*. Unfortunately, some difference prevails in the descriptions of this organ by the several observers, which it is most desirable to have removed. Carter (*A. N. H.* 1856, xviii. p. 221) represents it to be a cloudy body, "discoid in shape, of a faint yellow colour, and fixed to one side of a transparent capsule, which, being generally more or less larger than the nucleus itself, causes the latter to appear as if surrounded by a narrow pellucid ring." Stein describes it in *Actinophrys Sol* as finely granular, band-shaped, and curved, or reniform, or rounded oblong (XXIII. 1 *b*). Cienkowsky says that the nucleus of *Podophrya* is "transverse and frequently curved," and thereby implies that it is an elongated body. The nucleus of *Actinophrys oculata* (says Stein, p. 159) may be brought into view either by crushing the animalcule, or, much more satisfactorily, by adding dilute acetic acid (XXIII. 24 *b*, 25 *g*). On viewing it from above, it appears like a round hyaline cell, containing a granular nuclear mass in its centre, and surrounded by a rather condensed layer of the medullary matter. On its entire detachment, by means of the acid, it is seen to possess a distinct wall, having a double outline; its nucleolus, on the contrary, seems undefined and irregular in shape, composed of a mere heap of fine granules. The relative size of the nucleus to the whole animal is very considerable. Thus, whilst the majority of specimens had a diameter of 1-38 to 1-35''', the nucleus measured 1-125''', and its nucleolus 1-250'''. From his account of *Act. Eichornii*, Stein would appear to have seen a similar nucleus in that species; for he states that the round nucleus appeared like a nucleus-holding cell, having a double contour and clearly-defined wall, and containing a large, finely-granular nucleolus.

ENCYSTING AND REPRODUCTIVE PROCESSES OF ACTINOPHRYINA:—ENCYSTING—FISSION—GEMMATION—EMBRYOS—CONJUGATION.—Stein represents his *Actinophrys Sol* and *Podophrya fixa* as having a double integument (XXIII. 1, 3), through which the tentacles penetrate,—whilst, as we have seen, other observers insist upon the naked state of the muco-gelatinous body of those as well as of the other species of *Actinophryina*. The questions therefore arise, whether the being so named and described by Stein is identical with that intended by other naturalists, and, if so, whether it is not, in the so-called encysted condition, at least in its earlier stage. For Stein subsequently describes and figures truly encysted examples, in which the cyst appears like a plicated loose sac around the contracted body, and the tentacles in part or wholly gone (XVIII. 3). Cienkowski affirms (*op. cit.* p. 101) that the being described as *Actinophrys* by Ehrenberg is really a non-pedunculate *Acineta*; and he further remarks that, although numerous points of relation exist between certain *Acineta*-forms and *Podophrya fixa*, he is unable to determine whether they should be regarded as identical, or as the extreme links in the morphological cycle of one and the same species. The same critical observer details the process of encysting of *Podophrya*,—a process, by the way, which he has not met with in *Acineta*-form organisms having a general resemblance with it. To quote his account (*op. cit.* p. 99), "If *Podophryæ* are allowed to remain several days upon the object-glass, and care is taken not to let the water dry up, every stage towards the quiescent condition—that is to say, towards the 'encysting'—may be followed (XXIII. 34, 36, 37).

"In *Podophrya* this process takes place in the following manner:—On the surface of the body a gelatinous mucous layer appears to be secreted, through which the tentacles pass. The tentacles disappear in the neighbourhood of the peduncle; and the gelatinous layer in this situation hardens into a loose transversely-plicated membrane, whilst at the upper end it is still soft, and the tentacles clearly visible. Ultimately these also are retracted, and the entire body of the *Podophrya* is enveloped in a wide loose membrane; the plications are caused by parallel annular constrictions, placed at equal distances apart, and separated by circular, angular, or rounded ridges; these plications are in a plane perpendicular to the peduncle. At the summit of the *Podophrya*, and often also at the base, the membrane presents deep depressions; the inclosed body of the *Podophrya* acquires on its surface a sharply-defined smooth membrane, whilst the contents of the body become somewhat opaque, enclosing a round clear space. The *Podophrya*-cyst thus formed is supported by a peduncle, which is widened at the base. In many instances in which the membrane was not plicated, but loosely enclosed the *Podophrya* like a sac, I noticed that the peduncle of the cyst was continued uninterruptedly into the membrane, of which consequently it must be regarded as a protrusion, and that it had no connexion whatever with the original slender peduncle of the *Podophrya* itself. In fact, I noticed cysts in which this original slender peduncle was appended to the saccular envelope. I am unable, therefore, to adopt Stein's view that the *Podophryæ* are enclosed in a membrane, of which the slender peduncle is simply a tubular protrusion. This is true only with respect to the short peduncle of the encysted *Podophryæ*.

"What afterwards becomes of the cysts I have been unable, in spite of observations continued for months, to determine."

Multiplication by *Spontaneous Division* seems now to be sufficiently demonstrated. Ehrenberg and other earlier writers, indeed, mentioned the occurrence of self-fission; but their accounts were too uncertain and indefinite, and strong doubts prevailed whether they had actually witnessed that process, or the act of conjugation, to be presently noticed. Mr. Brightwell appears (*Fauna Infusoria of Norfolk*) to have confounded the two processes; for he says—"They multiply by division, so that two and sometimes three individuals are seen adhering together by their outer edge—the middle one, the parent, being the largest,"—an explanation inconsistent with the process of fission as generally understood. Claparède states distinctly that he has seen the act of fission; Weston describes it in *Actinophrys*, and Cienkowsky in *Podophrya*. "With regard to the reproduction of *Actinophrys Sol*," writes Mr. Watson (*op. cit.* p. 119), "I can positively affirm that self-division is one mode; for I may say I have witnessed it a hundred times and shown it to others.... First was noticed a deep depression above and below, not far from the centre of the body; this, as it increased, threw the tentacles across each other, in a manner similar to that described by Kölliker, when in the act of inclosing an object of prey. This crossing, however, in the act of self-division would appear to be only the necessary consequence of the depressions alluded to, and the position into which the outer membrane (in which the tentacles are inserted) is drawn. As division proceeded (XXIII. 31), the two animalcules steadily, but rather quickly, increased the distance between them, until the connecting medium was apparently a long membranous neck, which, to my unpractised eye, appeared composed first of four, then of three, then two irregular lines of cells (possessing no nuclei), which ultimately diminished into a single cord composed of three simple cells elongated like the links of a chain, this becoming gradually more attenuated, until the exact moment of its division could not be seen. All this latter portion of the process was rather rapidly performed,—that is, from the first formation of the rows of cells to the time of what I supposed to be the final separation, occupied only about a quarter of an hour.... During the whole of the process, the valve (*i. e.* the expanding and contracting superficial vacuole) of each segment, situated at nearly opposite extremes, was in constant action, and each creature was busily employed seizing its food." On following one segment after its separation, "a floating faint line, the broken thread" (of connexion), extended from it; and two of the cells, formerly contained within this bond, were attached to its side, but were in a few minutes drawn into the body of the *Actinophrys*, which there assumed a perfectly normal character. In *Podophrya* the process of fission is similar (XXIII. 34); at first an annular constriction displays itself, and so rapidly deepens, that in an about half-an-hour complete transverse fission is effected. The history of the segments is thus portrayed by Cienkowsky (*op. cit.* p. 98), about ten minutes after the commencement of the act of division:—"The upper segment had assumed an elongated form, was more cylindrical, a little indented in the middle, and rounded at each end; and at the extremities, slight oscillations to the right and left could be perceived. A transverse, and frequently curved, nucleus was visible in the fluid contents; and a lateral contractile space could be clearly distinguished in the upper parts. The vibrations increased in frequency and force until the segment became wholly detached and escaped. During the process of division both segments were furnished with tentacles; but when the oscillations of the cylindrical portion commenced, very fine and short cilia might be seen, though with difficulty, vibrating on the free end,—the tentacles at the same time being retracted, and remaining visible only on the posterior segment. I now followed uninterruptedly the movements of the liberated segments. They moved for the most part in curved lines, in the course of which the motile segment appeared to seek the illuminated side of the drop of water. Cilia could not be perceived over the whole surface. The contractile space during the movements was always in front. The motions were rapid, but still such as to allow of their being followed with a magnifying power of 370 diam. After waiting patiently for twenty minutes, I saw the motion cease; and at the same time short tentacles made their appearance, which were protruded more and more; and in a few minutes afterwards the segment regained the spherical form: thus, after moving about freely for a time, it was again transformed into a *Podophrya*.

"This process of division was witnessed by other observers. It takes place more especially when sufficient nutriment is supplied by numerous *Stylonychiæ* to the *Podophryæ*. The *Podophrya* does not always divide into two equal halves; the segments are more frequently unequal. After repeated division, the specimens always become more transparent." This temporary production of vibratile cilia from the surface of one of the *Actinophryina*, in connexion with the process of fission, is a phenomenon so opposed to received notions, that it will necessarily be admitted with great reserve until confirmed by repeated observation.

The process of *Gemmation* is recorded by Lachmann to occur in *Dendrosoma radians*, a being of which we know too little to pronounce with certainty if it be one of the *Actinophryina* or of the *Acinetina*. He says (*op. cit.* p. 231)—"In *Dendrosoma radians*, Ehr., a branch of the nucleus grows into the bud whilst it still remains united to the parent animal."

Reproduction by *Embryos* or *Germs* has been presumed by several authorities. Stein, in pursuing the history of the organisms he identified with *Actinophrys Sol* and *Podophrya fixa*, satisfied himself of the successive development in their interior of a ciliated germ, which he compared to the gemma of a *Vorticella*, into which, indeed, he supposed it subsequently to fully unfold itself (XXIII. 2, 4, 5). However, as before noted, Cienkowsky rejects the beings observed by Stein from *Actinophryina*, and treats them as *Acinetina*; yet he, at the same time, confirms the production of ciliated motile embryos within *Acineta*, but declares them reconverted into similar *Podophryæ* to those that give birth to them. Apart from the researches of Stein, which have invoked so much attention to the development of Protozoa generally, and particularly to that of *Actinophryina* and *Acinetina*, the idea that the members of the former family probably reproduce themselves by germs has been suggested by the occurrence of very minute individuals, either alone or in clusters. Thus Kölliker remarks (*op. cit.* p. 34) that the smallest individuals of *Actinophrys Sol* measured only 0·01‴ to 0·02‴, and presented very inconspicuous and few granules, and that the granular and vesicular corpuscles within the nuclear portion of the body may be germs just beginning to be evolved. Mr. Weston is also led to believe in the internal generation of minute germs; but the observation he records, as possibly an instance of such a process, entirely fails, in our opinion, to sustain the supposition. The occurrence alluded to was that of a thin, pellicular, irregularly-shaped sac—sometimes of two or three such,—which elevated itself above the surface of the *Actinophrys*, and presently burst, emitting some fluid and fine granular matter, and then contracted. "Does this emitted fluid," he asks, "contain the germ of future generations?" We think not; for, to our mind, the phenomenon witnessed was nothing more than the bursting of superficial vacuola, probably acting as excrementory media; and if this view be not correct, Mr. Weston's is improbable, inasmuch as such a discharge of germs from superficial sacs is without parallel in the history of Protozoa.

CONJUGATION.—The remarkable act of conjugation, also known as *Zygosis*, has attracted very much attention in the class of animalcules under consideration, among which it is of very frequent occurrence. Much discussion has taken place concerning the purpose of this process. Most of its early observers considered it a reproductive act, a sort of copulation between two individuals; but the tendency of opinion at the present day is to deny it this nature, and to treat it as little more than an accidental phenomenon, without apparent object or aim. Nevertheless its occurrence is so frequent, and the process of so complete a character, that it is hard to believe it to be in vain and to no purpose in the economy of the *Actinophryina*. A difference of opinion likewise prevails as to the nature of the process, one set of authors maintaining that there is an actual fusion and intermingling of substance between the conjugating animals, whilst another party asserts that there is no fusion, but merely a temporary adhesion or accretion between their bodies. The determination of this question is very necessary before we can speculate fairly respecting the purpose of the act. Kölliker, who was among the first to carefully explore this phenomenon, described it as a process of complete fusion, and surmised it to be of a reproductive character. Stein speaks at one place of conjugation (*op. cit.* p. 148) in *Actinophrys* and *Podophrya* as consisting in a fusion (*Verschmelzung*) of the animalcule. At another (p. 160) he describes it as an organic union of two or more individuals into a group, involving no fusion of their contents, but only a cohesion by their surfaces; and goes on to say (p. 161) that the coming together of two *Actinophrides* is due to external forces, and that the first thing observed is an entangling together of their tentacles, which act precisely in the same manner as when a foreign body is seized upon, and by their contraction bring the bodies into apposition. At the same time they fuse together and form a sort of commissure, which is sometimes areolated, owing to interruptions to its continuity by the incomplete confluence of the tentacles. In the case of *Act. oculata*, several—as many as seven—individuals were seen by Stein connected together, in a line, by this intermediate commissural matter, which he calls a common mantle,—but all of them preserving their individuality, just as in the instance of other species. This mode of connexion, by means of an interposed matter derived from the tentacula of the conjoined surfaces, explains what Stein means by conjugation being a fusion of the animalcules concerned—not a fusion or commingling of their substance in general, as some have thought it. Cohn, in his account of the conjugation of *Actinophrys* (*Zeitschr.* Band iii. p. 66), noticed the connecting band or commissure to sometimes contain, besides granules, particles of food, and vacuola, a vesicular body which he presumed to be nuclear, or a germ, developed as a consequence of the zygosis in operation. Stein encountered once or oftener a similar body, but concluded that it was accidental, probably of vegetable origin, and not in any degree embryonic; and (p. 164) he expresses himself satisfied that this act of conjugation is not associated with the reproductive faculty. In fact, he has never met with the development of an embryo in conjugated individuals of his (Acinetiform) *Actinophrys* and *Podophrya*. Claparède questions (*op. cit.* p. 286) whether the compound forms noted by Stein and Perty were, as they supposed, all derived from conjugation; and he proceeds to say that, if it be proved that more than two individuals may thus be fused together, the connexion of conjugation with reproduction will become exceedingly doubtful, and that the term had better be dropped, and either Stein's phrase "process of fusion," or Ehrenberg's word "zygosis," adopted in its room. Whatever value attaches to Claparède's deduction from the circumstance of more than two being fused together, there can be no doubt that this may, and indeed does frequently, happen. Lieberkühn, one of the most recent investigators of this group of beings (*Zeitschr.* 1856, 308), recognizes the occurrence, and observes that the number united may be estimated by that of the contractile vesicles. The process, he further asserts, is not one of genuine conjugation, but merely a temporary cohesion; for, after watching a group for six hours, he saw the separation of the several component individuals, preceded by a narrowing of the connecting bands or commissures. Such is an outline of the opinions and statements of some leading naturalists respecting the nature and design of this so-called act of conjugation. The balance of authority and evidence is against the supposition of its reproductive purpose; but when this view is rejected, we have no other to replace it, and are sensible of the want of sufficient data from direct observation before a hopeful attempt can be made. Ehrenberg, it should not be omitted to state (*Monatsb. Berl. Akad.* April 1854), started the notion that conjugation is intended as a means of invigorating the species: "a curious idea," says Claparède (*op. cit.* p. 286), "and not very reconcileable with the ordinary laws of nature."

Kölliker (*op. cit.* p. 100) canvassed the question, if Actinophryina, along with Rhizopoda, are to be considered cells, and, after an elaborate examination of the point, concluded that they must be regarded as peculiarly modified simple cells. Claparède, after weighing Kölliker's arguments and reviewing the structural peculiarities of these animalcules, comes to the opposite conclusion, viz. that, "as regards *Actinophrys Sol* in particular, we must either drop the class of unicellular animals altogether, or refer this animal to some other place." We do not deem it at all necessary here to enter upon this controversy; it has already engaged our attention in other places, and has of late lost much of its interest by the extended modifications introduced latterly in that particular hypothesis of cell-nature, which, at the date of Kölliker's paper in 1849, exerted so powerful an influence over the histological speculations of all the writers of that period.

LOCALITIES.—*Actinophryina* are inhabitants both of fresh and salt water. They occur often as parasites upon the larger Protozoa, such as *Stylonychia*, and on various small animals of other classes, and seem to draw nourishment from them. They are also common among the filaments of *Conferva* and the stalks of *Lemna*, where other animalcules congregate. Another locality is amid the vegetable débris and minute animals which often float together, as a dust-like film, on the surface of ponds.

AFFINITIES OF ACTINOPHRYINA.—All recent writers refer this group of beings to the Rhizopoda, except Siebold, who curiously enough retains *Actinophrys* in the family *Enchelia*, along with *Leucophrys* and *Prorodon*, two genera of Ciliata of quite a different type of organization. Although the preceding sketch of the history of *Actinophryina* will afford ample evidence of many homologies with the Rhizopoda, yet it will equally display not a few differential characters, sufficient, we believe, to separate them at least as a subclass.

The most striking points of divergence are the more definite and constant figure of *Actinophryina*, their peculiarly formed tentacula in lieu of ordinary variable processes, and, of minor moment, their greater immobility, and the operation of the tentacles in the introduction of food. *Acineta* was placed by Ehrenberg with *Actinophrys* in a family or order *Acinetina*; and most writers treat them as if the relation between these two families were actually so near. A closer attention will, however, prove that something more than a generic difference subsists, and that *Acineta* had better stand as the representative of another group, well named *Acinetina*, although more limited in its signification than that so termed by Ehrenberg. The most tangible differences between *Actinophryina* and *Acinetina* are, that no food enters the substance of the body in the latter group, and that the body is covered with an integument. The history of this division, as far as at present known, reveals yet other distinctions; for self-division has never been observed, whilst the production of motile ciliated embryos from the interior has been seen over and over again, without, as far as is known, an antecedent act of conjugation. It must likewise not be forgotton, that it is the *Acinetina* which, according to Stein's hypothesis, constitute an intermediate phase of existence in the development of many *Vorticellina*. Indeed, could this naturalist's supposition be proved, the existence of *Acinetina* as a class of independent beings would at once be sacrificed. Another affinity is discoverable with the *Polycystina*, both in the nature of the soft, muco-gelatinous mass, in the long, tentacular filaments, and in the currents of granules detected in the processes. This relation is best seen with some *Acanthometra* (*vide* Müller's paper, *Monatsbericht*, Berlin, April 1855). The *Actinophryina* are related to the Ciliata also by their sarcode, by the structure and action of the contractile vesicle, by the formation of alimentary vacuoles, and by the nature and composition of their granules. But, over and above these general resemblances, a more special affinity is manifested if Cienkowsky's statement, that the fission produced is clothed with vibratile cilia, be correct. This degree of affinity must be admitted in the case of the *Acinetina* which appear, as a rule, to generate ciliated embryos.

Since the above history was written, Dr. Strethill Wright, of Edinburgh, has most kindly furnished us with notes on several Infusoria, among others of two new forms of *Actinophryina*, presenting great peculiarities in structure. The account of these novel genera will be found in the second part of this work, in the Systematic History of the *Actinophryina*.

SUBFAMILY ACINETINA.

(Plates XXIII. 1–23; XXVI. 3, 4; XXX. 3, 4, 7, 8, 21–26.)

The reasons for separating *Acinetina* from *Actinophryina*, with which they have generally been united, have been stated in the last chapter, where likewise the differential characters of the two groups, and the supposed part they play in the cycle of development of *Vorticellina*, have been examined. There remains therefore, to fill up the history of the *Acinetina*, nothing more than some further remarks on the various forms they assume, and on certain peculiarities in their structure.

The form of *Acinetæ* is subject to great variety. Pyriform and ovoid shapes are the most prevalent; but some are almost spherical, and others, again, nearly triangular (XXIII. 6, 7, 8, 15, 17, 22, 23). A lobulated anterior end is common; and then the tentacles are usually restricted to the lobules (6, 17, 18). These lobed forms have no such firm integument or capsule at all as that seen in others; or the anterior lobed part is undefended by such a covering, except of a very delicate and yielding structure. Cienkowsky speaks of the *Acineta* he examined as naked without limitary membrane (XXIII. 40). Very frequently, on the other hand, the *Acineta* is entirely enclosed within a stout capsule. This capsule is readily discerned when, as frequently happens, the internal animal mass of the *Acineta* does not fill it; or it may be brought into view by the application of diluted acetic acid or alcohol, either of which causes the shrinking of the contained body. In general the capsule appears to be a very thin, colourless, hyaline membrane; but after the action of acetic acid, Stein represents it to be, in the supposed *Acineta* of *Opercularia Lichtensteinii*, of considerable thickness (XXIII. 22, 23). This thickening is doubtless due to the action of the acid in causing the membrane to swell out. With the exception of the so-called *Actinophrys Sol* of Stein, and the *Dendrocometes*, the *Acinetina* are attached by a stalk of varying length, more commonly very short, to the body on which they live (XXIII. 17, 18, 22; XXVI. 3, 4). This stalk or pedicle is a tubular prolongation backwards of the capsule itself, like which, it is hyaline and transparent.

It is not articulated with the body of the *Acineta*, but expands more or less abruptly into the capsule, and has a proportionately greater or less infundibuliform figure. Occasionally the stem at the upper part has transverse rugæ, and in a few instances exhibits a sort of longitudinal striæ, particularly near its junction with the body (XXIII. 3, 4). Stein describes the stem of the supposed *Acineta* of *Epistylis*, to be solid like that of an *Epistylis* itself. Frequently the capsule is thrown into transverse folds, at times, of considerable depth. There is no aperture in it; but it is penetrated by the tentacles which rise from the contained organic being. The capsule, if in some specimens of considerable firmness, would seem to be in others, even when thick, very yielding,—so much so as to allow great variety in figure by the contractions of the contained body, as instanced by Stein in the *Acineta* attributed to *Opercularia Lichtensteinii*. The tentacles of *Acinetina* have not the uniformity of structure seen in those of *Actinophryina*. In some *Acinetæ* they closely resemble those of *Actinophrys*, are long, gently tapering, and capitate; in others they form parallel tubular processes, dilated a little, or not at all, at the extremity, and either straight or slightly curved or undulated; in others, again, they rather resemble bristles, appear stiff, and taper to a sharp point. In the remarkable *Acineta* called *Dendrocometes*, the tentacular character is entirely lost, and a few most bizarre branched tubular processes spring from one to six points of the surface (XXX. 22, 23). Perhaps these processes are homologous with tentacles; yet, unlike them, they seem to be formed from the capsule of the animal, into which the granular contents of the interior penetrate, as into hollow tubules prolonged from the surface of the organism.

In certain *Acinetina* that approach *Actinophrys* in external characters, the tentacles are equally diffused over the body. In the large pyriform *Acineta*, assigned by Stein to *Opercularia articulata*, the short slender tubular processes appear chiefly marginal (XXX. 3, 4). The digitate *Acineta* is covered by long tapering and thick processes on its dorsal convex surface (XXIII. 21); and the Diademiform *Acineta* has its long setiform tentacles in twos and threes at considerable intervals, chiefly on the margin (XXIII. 15, 16). The *Actinophryean Acineta* of *Epistylis plicatilis* bears a bundle of long finely capitate tentacula on each of its four lobes (XVIII. 2); that of *Vorticella nebulifera* has two such bundles,—whilst the triangular *Acineta*, with its tongue-like process (XXIII. 17, 18, 19), carries a large expanding pencil of shorter obtuse tentacles upon each angle at its base.

The tentacula are moveable and retractile, the divergent bundles may be collected into parallel groups, and drawn inwards, with the protruding supporting lobes, to a greater or less extent. Stein affirms that, in the first stage of development, *Acinetæ* have no tentacula.

The body of an *Acineta*, within the capsule or external integument, consists of soft colourless sarcode, rich in granules, fat-corpuscles, and minute globules. It is enveloped by an elastic yielding membrane, which becomes most distinct when the body shrivels within the capacious cavity of the capsule (XXIII. 3, 6, 8). The body appears in some *Acinetæ* capable of extending itself above the capsule, which must therefore be fissured in front, in the form of a tongue-like process (XXIII. 17, 18, 19). A finely granular and opaque nucleus is always distinguishable in the interior, usually near the centre. Its shape is very varied, and may be oval, ovoid, clavate, reniform, band-like, vermiform, or horse-shoe shaped (XXIII. 1, 6, 17, 22). In a few examples, *e.g.* of the supposed *Acineta* of *Opercularia*, it is much and irregularly branched (XXX. 3, 4). The addition of dilute acetic acid is a ready and effectual means of bringing the nucleus to light, and of demonstrating its enclosing sac; and as it is more solid and compact than the contents around it, it may now and then be separated by crushing the *Acineta*. The nucleus is enveloped by its peculiar membrane; a fact which becomes evident in several cases by the apparent double line surrounding its granular mass (XXIII. 6-22). In a few instances, moreover, Stein has described a contractile space within the nucleus, *e. g.* in that of *Opercularia berberina*.

Not unfrequently the nucleus looks as if double, or as sending off a process from itself; a critical examination of such specimens has convinced Stein that the offshoot is the commencing development of the germ or embryo of the *Acineta* (XXIII. 7, 8, 19). This he has proved by watching the nucleus through all its intermediate stages, from a simple ovoid or elongated figure until the embryo has grown and separated itself from it prior to its escape from the *Acineta*. The nuclear appendix, when separated, is found to have an enclosing membrane, which ultimately surrounds the embryo like a sac, and admits of a certain degree of movement within it (XXIII. 4, 5).

Another distinct organ of *Acinetina* is the contractile vesicle. Usually one only is present; but in some instances two, and more rarely three or more, make their appearance (XXIII. 1, 5, 21). Near the external margin a series of clear vesicular or vacuolar spaces presents itself, as in the Diademiform *Acineta* (XXIII. 15, 16); such, however, present no rhythmical contractions, and cannot be regarded as true contractile sacs. The embryos developed from *Acinetæ* are likewise furnished with one, and occasionally with two, of those organs (XXIII. 2, 4, 5, 15, 27). Excepting the embryos or germs, no other special structures are seen amid the granular contents of *Acinetina*. Alimentary vacuoles and particles of food or other matters derived from without never make their appearance; for the body, even if not entirely enclosed within the shut sac or capsule, is covered with an integument, and has no sign of a mouth for the admission of food. Yet *Acinetæ* generally have the power of nourishing themselves, by the medium of their tentacula, which appear to act as suckers, drawing in by endosmosis the nutrient juices from the animalcules which get entangled by them.

If Stein's details be correct, some Acinetiform beings would appear to have no power of self-nutrition; for their substance is described as gradually used up in the formation of germs, and this decrease to be followed by a shrinking or collapse of the capsule, but at a comparatively slower rate. This phenomenon is illustrated by Stein in the *Acineta* ascribed to *Vaginicola* *crystallina*, and in the so-called *Acineta* with the tongue-like process (XXIII. 17, 20).

If this account be admitted, that certain *Acinetæ* display no power of self-nutrition, and seem destined only to subserve, as mere media, the purposes of reproduction, an independent nature could scarcely be attributed to such beings, and their history would be entirely comprehended in that of the beings in whose cycle of development they might enter as one link. Lachmann (*A. N. H.* 1857, xix. p. 222) has the following account of the mode in which *Acinetina* nourish themselves:—"Each ray" (tentacle) "is a sucking proboscis, and we soon see that a current of chyme-particles runs from the alimentary cavity of the captured Infusorium into the body of the *Acineta*, through the axis of the rays, which, after seizing the prey, have become shortened and thickened. In the body of the *Acineta* the chyme-particles still run at first in a slender row, but afterwards they collect in a drop, which although drops are also formed in the chyme of the *Acineta* by other suckers, soon becomes amalgamated with these. When a considerable quantity of the chyme of the captured animal has passed over into the body of the *Acineta*, a remarkable change gradually takes place in its appearance: if it was previously pale, nearly transparent, and only very finely granulated, larger dark globules, resembling fat-drops, now make their appearance here and there; and these soon increase so that the body (which at the same time, of course, increases in thickness) acquires a coarsely-granular aspect, and becomes opaque. The globules or drops which make their appearance can only be formed in the body of the *Acineta*, as they are far larger than the chyme-particles which are seen flowing through the sucker. The animal whose contents are thus sucked out, gradually collapses and dies; many become liquefied when only a little of the chyme is extracted from them, others still live for a long time; in large animals, such as *Stylonychia Mytilus, Paramecium Aurelia*, &c., the sucking often continues for several hours."

Origin and Development of Acinetina.—In our history of the development of *Vorticellina*, Stein's hypothesis of the transformation of those highly-developed Ciliata into Acinetiform beings as a stage of existence necessary to their development by embryos, and of the reconversion of the embryos into Ciliata of the primitive type, is sufficiently enlarged upon. In the same chapter, moreover, Cienkowsky's contradictory statement and observation are detailed, viz. that, though *Acinetæ* develope ciliated embryos, yet these embryos give origin to beings like those they issue from, and are not transformed into *Vorticellina*. According to this opinion, the *Acinetina* take a position as independent beings in the animal series. Stein determined, to his own satisfaction, an Acinetiform phase in the following *Vorticellina* and *Ophrydina*:—

Cothurnia maritima.	*Spirochona gemmipara.*
Epistylis branchiophila.	*Vaginicola crystallina.*
Opercularia articulata.	*Vorticella microstoma.*
Opercularia berberina.	*Vorticella nebulifera.*
Opercularia Lichtensteinii.	*Zoothamnium affine.*
Ophrydium versatile.	*Carchesium pygmæum?*

The description of the Acinetiform beings assigned to the species enumerated is given in the Systematic History of the *Acinetina*, which will likewise afford a more complete idea of the structure and forms of this peculiar class of beings than the above general history itself.

SUPPLEMENTARY FAMILIES OF PROTOZOA.

A.—GREGARINIDA. THEIR GENERAL CHARACTERS, STRUCTURE, AND AFFINITIES.—The *Gregarinida* constitute one of the three groups into which several eminent naturalists subdivide the Protozoa; they therefore claim from us a brief description.

They are of the most simple structure; indeed, some writers place them below the Rhizopods in the animal series, because, unlike these, their simple type undergoes no further elaboration or developmental complication. They are parasites, living in the visceral cavities of other animals, and in their simple structure are comparable to a cell, or to the ovum of higher animals. Thus they consist of a homogeneous albuminous-like matter, with numerous granules of coarser and finer character and fat-like globules, enclosed within a membrane of more or less perfect structure, which in all essential points represents a cell-wall; besides, they have always one distinct central vesicular body or space containing one or more granules, and evidently of the nature of a nucleus. Of these parts, the general mass may be taken to resemble the yelk-matter, and the nucleus the germinal vesicle of an ovum.

The enclosing membrane is very yielding, and admits of great and constantly fluctuating alterations of figure by the varying contractions and extensions of the internal contractile mass; but there is no such thing as the formation of pseudopodes, as happens among Rhizopoda. It is entire, without orifice either in the shape of a mouth or anus; consequently no foreign particles are ever seen in the interior. Moreover, the *Gregarinida* contain no contractile vesicle, and have never been found to undergo either fission or gemmation. Their vital endowments are so slight, that their animality is at first sight doubtful; but, unlike vegetable organisms, their envelope contains no cellulose.

The above brief account comprehends all that can be stated generally of the organization of these simple creatures, which, if above the *Amœbæa* in the possession of a more or less definite membrane, yet sink beneath them in not possessing a contractile vesicle.

Notwithstanding their simplicity of structure, they yet are truly animal organisms, enjoying an independent existence, manifesting the phenomena of motion, growth, nutrition, and reproduction, in the last of which they exhibit a peculiar cycle of changes.

Moreover, there are various notable differences between the various *Gregarinida* known, with respect to size, figure, to the activity of their functions, and to some minuter points of structure. Hence their division into genera and species.

In size they vary from four or five lines (as in the genus *Didymophrys*) to a few thousandths of an inch. Of their figure, some are simply rounded or oval sacs, as in *Monocystis*; others constricted around the middle, *e. g. Gregarinida.* Again, the majority have a smooth, naked membrane, whilst others are armed with a ring of uncini at one extremity, like many *Helminthidæ.*

When two nuclei occur in a single animal, it probably betokens an act of reproduction. The encysting process is exhibited among the *Gregarinida*, in connexion, however, only with their reproductive processes, and has this peculiarity, that it does not occur to a single individual, but to two together, which become enclosed within the common cyst or capsule. In their progress to this union the two *Gregarinæ* are seen first to approach, and then by mutual pressure to flatten, the opposed surfaces, so that the binate being acquires a globular form. The substance to form the cyst is in the meantime thrown out, of a soft gelatinous consistence, but gradually becomes condensed and contracted into a membranous-looking capsule.

Stein stated that, on the completion of the act of apposition, an actual fusion of the contents of the two animals transpired, the opposed walls being previously removed by absorption. Other observers state, however, that there is no such removal of the external membranes, and that the reproductive processes in the interior of each being proceed without any real commingling of their contents, which is a subsequent and probably not a necessary event.

This act, which, from its general resemblance to the zygosis of plants, is spoken of as one of conjugation, appears immediately concerned in the development of a multitude of germs within each *Gregarina*, by the general breaking up of the granular contents. Still, if Lieberkühn's account be admitted, this process of conjugation is not a necessary prelude to the development of the internal germs; for, according to it, this result may accrue in individuals which have never conjugated.

The germs assume a rod- or spindle-shaped figure, which, from its resemblance to the prevailing form of the *Naviculæ*, has suggested for them the name of "*Navicellæ*" or "*pseudo-Navicellæ*." They consist of an external comparatively firm wall, enclosing a finely-granular gelatinous substance.

When the "*Navicellæ*" are sufficiently mature, the cyst of the *Gregarinæ* bursts and sets them at large. Their future history, according to Lieberkühn's researches, is, that the case of each *pseudo-Navicella* ruptures and gives exit to the soft contained matter, which at first much resembles a minute *Amœba*, but gradually assumes, by progressive growth and the formation of a pellicle around it, the characters of a *Gregarina*.

Between this mode of development of *Gregarinida* and that of the Ciliated Protozoa, Leuckart draws this distinction, that in the former it consists in the production of granular germs, in the latter of living embryos. But it may be questioned whether there is a positive difference in kind between these two results of the reproductive process, and whether, on the contrary, the *Navicellæ* of the *Gregarinida* may not be considered as merely encysted embryos, homologous with those of *Colpoda Cucullus* among the Ciliata.

The act of conjugation in the *Gregarinida* is not precisely like that occurring among the lower Algæ, the leading difference being that in the former there is no commixture of the two approximated beings. In all essentials, indeed, conjugation in this family resembles that believed to happen in the *Actinophryina*.

There has been much dispute whether the *Gregarinida* are to be held independent animals, or merely embryonic phases of others; the balance of authority is in favour of the former view. Kölliker and Leydig advocated the opinion that they are metamorphic stages of *Anguillulæ* or *Filariæ*, or a link in the series of development of the *Helminthidæ*. The arguments adduced by Leydig are thus briefly stated (*J. M. S.* i. p. 208, and *Müller's Archiv*, 1851):—"In the intestine of a large species of *Terebella* he was enabled to observe the most distinct transition between Filaria-like Nematoid worms and *Gregarinæ*. The forms of the latter, which he observed not once only, but many times, were—1. A *Gregarina* of from 0·02‴ to 0·04‴ long, which had the form of an elongated sac, rounded at one extremity, and sharp at the other. The contents were those usual in the *Gregarinæ*—a consistent fluid with a corpuscular substance, which did not occupy the pointed end, and imbedded in this a clear vesicle with a nucleus. 2. A Gregariniform creature, of a spindle-shaped figure, closely resembling *Gregarina Terebellæ*, Köhl. 3. A *Gregarina*, generally resembling the preceding, differing only in two particulars: the internal substance is arranged in longitudinal streaks; and the body, instead of being straight, is more or less curved at each end.

4. The same form, but with the body more elongated, vermiform, and for the first time exhibiting motion. 5. A very pretty Nematoid worm, about 0·10″ long, blunt at one end, sharp at the other; the contents in longitudinal streaks, as in the two preceding forms, but with the spaces between them wider. Its motions are very active."

This view of a metamorphosis being admitted, the question arises, do the *Gregarinæ* become changed into *Filariæ*? or is it that the *Filaria*-like worms are transformed into *Gregarinæ*? Although at first inclined to consider the former as the true state of the case, Leydig is now disposed to follow Henle and Bruch, and adopt the latter view; otherwise it would seem impossible to account for the formation of the *pseudo-Navicellæ* and "*Psorospermia*" within the "*Gregarinæ*."

Kölliker has the following remarks on this subject (*J. M. S.* i. p. 212):— "Although the change of a *Filaria* into a *Gregarina* is not an impossible circumstance, before we admit such a thing it is first necessary to inquire whether the facts stated may not be otherwise explained. It is by no means proved that the *Anguillula*-like animal noticed by Henle, and termed by Bruch *Filaria*, is really a Nematoid worm." Kölliker is more inclined to regard it as an Infusorium allied to *Opalina*, *Proteus*, &c. If this be the case, there is nothing extraordinary in its transformation into a *Gregarina*, and finally into a *Navicella*-receptacle.

"For many reasons," says Stein (*Zeitschr.* iii. 1852), "the endeavour to show the *Gregarinæ* to be larvæ of higher animals, and especially to connect them with encysted Nematoid worms, appears to be a vain attempt. Thus, I am acquainted with *Gregarinæ* of such peculiar forms that one requires a very strong imagination to deduce them from *Nematoidea*, or to suppose they can pass into these. The encysted *Nematoidea* are always found in the cavity of the body of insects, never in their intestinal canal, where alone encysted *Gregarinæ* are to be found." Again, the cysts of the *Nematoidea* of insects are made up of nucleated cells, and are plainly a product of the vital activity of the insects, not the exudation of the enclosed worm, while the cysts of *Gregarinæ* are produced as an amorphous secretion from the animals themselves. "If, therefore, encysted *Nematoidea* change into *Gregarinæ*, or *vice versâ*, their cyst must undergo a metamorphosis which, perhaps, no one will assume, and of which no observer has seen anything."

Lieberkühn's observations have gone far in showing that, under usual conditions at least, the *Gregarinida* are not converted into *Filariæ* or any other form of Vermes, but that their germs, after a short-lived Amœbiform period, not amounting, however, to a true metamorphic stage, assume the characters of their parent. Thus the cycle of development of these beings appears complete; the saccular animal constructs, by a process of segmentation of its internal substance, a host of germs, which, after breaking loose from their parent and involving its destruction, emerge from their cases in a soft Amœbiform condition, and soon acquire the mature Gregariniform condition. The *Gregarinida* exhibit a marked affinity with other Entozoa, particularly with the *Trematoda* and *Opalinæa*; and, as before remarked, they are allied with the *Amœbæa* in the extreme simplicity of their structure. By the possession of a limiting membrane (not independent or separable, indeed), they stand between the mucilaginous fluctuating *Amœbæa* and the Ciliated Protozoa. Unlike the *Amœbæa*, they do not receive into their substance solid particles, —a circumstance explicable by their being covered by a somewhat resistant, hardened lamina or tegument, which necessarily impedes that peculiar intussusception of solid matters witnessed in that family.

As to habitat, the *Gregarinida* are parasites in the intestines of various Invertebrate animals—worms, mollusks, and insects,—but have not been found in Vertebrata.

B.—PSOROSPERMIA (Plate XXII. 37–41).—This is a small group of parasitic animals, first observed by John Müller in 1841, closely related to the *Gregarinida*, of which, indeed, they might be included as members. Unlike the *Gregarinæ*, they live upon vertebrate animals, viz. upon many species of fish, about their skin, gills, and internal organs, several together enclosed within sacs.

Leydig has more recently applied himself to the study of these minute parasites, and has given the results of his observations in Müller's *Archiv* for 1851, of which an abstract appeared in the *Journ. of Mic. Science*, i. p. 206, which we shall here take the liberty of using, as sufficient for our purpose:—

"The *Psorospermia* are microscopical corpuscles of a peculiar kind, which may be generally characterized, in the full-grown condition, as rounded organisms, having a sharply-defined outline, with or without a tail-like appendage. They are flattened and lenticular in figure, and one pole is usually acuminate; and towards this pole several internal vesicles converge in a symmetrical manner. These creatures were discovered by John Müller in 1841 (Müll. *Archiv*, 1841, p. 477). He found in a young pike minute round cysts in the cellular tissue of the muscles of the eye, in the substance of the sclerotica, and between this and the chloroid coat. The contents of the cysts was a whitish substance, which, when examined microscopically, was found to consist of peculiar elements—the '*Psorospermia*.' [A detailed notice of these observations is given in the *Microscop. Journal*, vol. ii. p. 123, and in the *Brit. and Foreign Med. Rev.*, January, 1842.] In the following year the same observer (Müller's *Archiv*, 1842, p. 193) discovered parasitic corpuscles in the swimming-bladder of a *Gadus Callarias*, which, although specifically distinct from the *Psorospermia*, approached very near to the latter in their organization. They resembled in general a smooth ventricose *Navicula*, and consisted of two elongated cases applied to each other at the cavity, and with an elliptical outline and convex outer surface. They were in part free, in part enclosed in masses within a tunic. Similar cysts, containing *Psorospermia*, have been found by Leydig in several species of fish, and in all parts nearly of their bodies, and even in the blood contained in the heart and in the peritoneal cavity.

"Some facts, however, observed by him, connected with this subject, which came under his notice in 1850, during some researches on the cartilaginous fishes, served to throw a more general light upon these mysterious forms.

"In the gall-bladder of a *Squatina Angelus* there occurred in the bile, and in large quantity, peculiar forms of various organization, but which were manifestly developmental forms:—1. Rounded vesicles, consisting of a delicate membrane and a consistent fluid; the latter was of a yellow colour, and contained a multitude of also yellow granules. 2. Other vesicles presented, besides these, other elements of a new kind: in the middle of the granular contents were several perfectly transparent cellules; small vesicles had only one of these cellules, larger ones as many as six. 3. Other parent vesicles, again, exhibited, besides their membrane, a granular contents and secondary vesicles, containing *Psorospermia*, always one in each secondary vesicle. 4. In the latter form, finally, the secondary vesicle had attained a large size, and the Psorosperm floated in a spacious clear chamber, which occupied nearly the whole of the parent cyst. Besides these motionless cysts, there were numerous free *Psorospermia* in the bile.

"He found, upon examination, very similar things in other fishes of the same class,—as in *Spinax vulgaris, Scyllium Canicula, Torpedo Narke,* and *Raja Batis*, in which the *Psorospermia* differed from the more usual form, in being grooved or ribbed.

"It was very remarkable that the above-described organisms were never met with in any other part or tissue of the body than the gall-bladder or biliary duct.

"With respect to the nature of these bodies, Leydig is inclined to think that the cyst should be regarded as belonging to the family of the *Gregarinæ*, and that the *Psorospermia* must be looked upon as generically analogous to the *pseudo-Navicellæ* which have been observed to be generated within the *Gregarinæ*.

"The question next arises, as to the existence of similar Gregariniform organisms producing *Psorospermia* in fresh-water fishes. Leydig thinks there is reason to suppose that the animalcule discovered by Valentin in the blood of *Salmo Fario* is a *Gregarina*. Moreover, John Müller and Leydig have observed two or three ecaudate *Psorospermia* in *Leuciscus Dobulst* enclosed in a cyst,—whence it might be supposed that secondary cells may be developed within one of Valentin's Hæmatozoa after it has been conveyed in the course of the circulation to one organ or another, in which cells *Psorospermia* may originate. With the growth of the latter, the granular contents of the *Gregarinæ* gradually disappear, which are thus transformed into cysts filled with *Psorospermia*. Such a cyst would then be equivalent to a *Navicella*-receptacle."

Prof. Huxley, in his Lectures on Natural History (*Medical Times*, 1856, xxxiii. p. 508) has the following account:—

"The *Psorospermia* are pyriform sacs, frequently provided with an elongated, filiform, motionless appendage, and containing two or four clear rounded bodies, attached side by side, within their smaller ends, and besides these, as Lieberkühn has lately pointed out, a rounded mass of plasma. Under fitting conditions, the *Psorospermia* burst, and the plasmatic mass emerges as an Amœbiform creature. The sacs in which the *Psorospermiæ* are developed, on the other hand, can be traced back to Amœbiform masses full of granules; and it seems a legitimate conclusion, that the *Psorospermia* are the *pseudo-Navicellæ* of an Amœbiform *Gregarina* or Gregarinoid *Amœba*."

SUBSECTION II.—CILIATA.

(Plates XXIV.-XXXI.)

According to the arrangement we have adopted (p. 200), the Ciliata, as a subsection of Protozoa, are divisible into two groups:—1. Of such as are mouthless; 2. Of those possessing a mouth. The former group constitute the *Astoma*, the latter the *Stomatoda*.

In Ehrenberg's system the *Astoma* were not recognized; for where he did not find a mouth in any ciliated *Polygastrica*, he nevertheless assumed its existence, snpposing that from its minuteness, or some other cause, it merely escaped observation. This procedure was, indeed, rendered necessary by the hypothesis with which he set out, of their polygastric organization.

It must be admitted, to Ehrenberg's credit, that recent researches have proved him right in assigning a mouth, in by very far the largest number of Ciliated Protozoa, contrary to the assertions and opinions broached by many of the most eminent microscopists a few years since. Yet there is a limited number of mouthless Ciliata, independently of the peculiar family represented by the genus *Actinophrys*, placed very erroneously in the family

Enchelia by Ehrenberg, which must be separated not only from Stomatoda, but also from the Ciliata. This separation we have carried out, in constituting the two groups *Actinophryina* and *Acinetina*, intermediate between Rhizopoda and Ciliata. Excluding these very remarkable creatures, the Ehrenbergian families comprehended in our history of Ciliata are the *Peridiniæa, Dinobryina, Vorticellina, Ophrydina, Enchelia, Colepina, Trachelina, Ophryocercina, Aspidiscina, Kolpodea, Oxytrichina*, and *Euplota*.

Among the *Trachelina* were enumerated those very simple parasitic beings which late observations have proved to be mouthless, and are referred chiefly to a genus *Opalina*. These we therefore abstract, and, treating *Opalina* as the type, have constituted a new family, *Opalinæa*, a member of the group Astoma. In connexion with this we have placed the very imperfectly known *Peridiniæa*, although some recent writers seem disposed to attribute to them the possession of a mouth and digestive apparatus. The organization of the *Dinobryina* is, if possible, still less understood; and since we have no other descriptions of it than those supplied by Ehrenberg, we shall allow it to be mustered with the other ciliated families named in the large group of Stomatoda.

Group A.—Astoma, Astomatous or Mouthless Ciliata.

FAMILY I.—OPALINÆA.

(Plate XXII. 46, 47.)

General Characters and Functions.—This family, represented by the genus *Opalina*, consists of minute miscroscopical animalcules, moved by vibratile cilia distributed generally over the body, without mouth, of an oval or oblong compressed figure, living parasitic in the interior of larger animals, upon whose juices they nourish themselves. Their contents consist of a finely-granular substance, hollowed out into a small number of vesicular spaces, with no contractile power; extending through the centre is an elongated band-like (ligulate) nucleus, enclosed by a definite but delicate membrane, and composed of a homogeneous finely-granular substance. In two species, *O. Planariarum* and *O. uncinata* (XXII. 46, 47), a large pulsating vascular canal is found; the latter species is also furnished with strong hooks, whereby it effects its attachment to the intestinal surface, from which it draws its nutriment. Propagation takes place by transverse self-division, and also, in the opinion of a few observers, by germs or embryos. The *Opalinæ* are composed of sarcode enveloped by an integument, and rapidly undergo diffluence. In several species the existence of a mouth has been surmised,—for instance, by Ehrenberg in *Bursaria* (*Opalina*) *Ranarum*, and by Dujardin in *Opalina Lumbrici*. All doubt on this point may be always removed, Stein tells us (*op. cit.* p. 181), by using chemical reagents, such as alcohol, acetic acid, or weak solution of iodine, which destroy the fold, and prove no real opening to exist. If further proof were wanted, the constant absence of foreign particles in the interior might be adduced. This absence of a mouth affords evidence of the merely transitional nature of *Opalinæa*; for the same feature prevails in the case of embryos produced from the *Acinetina*, &c.

The vesicles or, as Dujardin calls them, "vacuoles," seen in greater or less number in all the *Opalinæa*, are irregularly disposed in the interior, and, according to this author and Stein, have no limiting membrane. However this may be, they remain clear and transparent when the rest of the contents are coloured by the bile of the animals the *Opalinæ* inhabit. This fact, moreover, attests another, viz. that they cannot owe their formation to fluids received from without, but that it must depend on the peculiar properties of the contents themselves. The formation of vacuoles in *Opalinæ* was adduced to disprove the origin of the alimentary globules in the Ciliata generally by the introduction of liquid from without; but it is to be remembered that in these two groups of organisms we have very different structural conditions, and that in the Ciliata the entrance of water mostly holding solid particles in suspension, through the œsophagus, and the moulding of it into a more or less spherical outline, are matters sufficiently proved by direct observation. We have stated above, that the vesicles are not contractile; Dujardin has, however, described those of *Leucophrys striata* as irregularly so.

The cilia are disposed in longitudinal lines, and in some instances, where there are ridges or margins, present a greater length and thickness, as, for instance, upon the edges of the curved surface by which the *O. Planariarum* adheres.

The surface can throw itself into plaits or folds,—an occurrence, however, probably limited to animals in a diseased or dying state, as Perty remarks in speaking of *Opalina Ranarum* (*op. cit.* p. 156).

The *Opalinæa* are not very active; they swim onwards, moving at the same time in an oscillating manner.

The above account comprises all that can be stated of the *Opalinæa* generally, since the differences in internal structure among the several reputed species are so great, that it constitutes, as Stein points out (*op. cit.* p. 182), a strong argument against the existence of the family as a group of independent beings. However, from the study of the peculiarities of the several members of the admitted genus *Opalina*, this author reduces them to three types, viz.:—1. The most common form of *Opalina*, represented by the *Leucophrys striata* of Dujardin, has an oblong body, marked by some 35 longitudinal granular striæ, and contains a number of vacuoles varying according to external conditions, and a central band-like nucleus. This animalcule occurs in the interior of the common earth-worm (*Lumbricus*). Stein found them of different lengths from 1-60''' to 1-14''', and in all stages of the process of transverse fission. When placed in water, they become more active. 2. The second form differs from the preceding by the irregular distension of the body when placed in water: a strong endosmotic currents sets in through the enclosing wall and raises it from its contents, so that these at length produce the appearance of a smaller *Opalina* enclosed within a large one. Dujardin has described this variety under the name of *Leucophrys nodulata*. This Stein would unite with the first named, under the term of *Opalina Lumbrici*, which, indeed, Schultze applied to the same animalcule. 3. The third modification of *Opalina* might be treated as an independent species; for, notwithstanding a general resemblance, it has a striking peculiarity of its own, visible under a strong magnifying power (such as 100 diameters), in the shape of a single, strong, horny apparatus, placed near the anterior end on the flat abdominal surface of the animal (XXII. 47). From a short common base situated to the right of the median line, slightly curved, uncinate, pointed processes are given off, of which one is much longer and stronger than the other. To the left of this organ a fold or furrow occurs in the surface, which might be mistaken for the entrance to a mouth. The development of this organ may be readily followed during self-division. It appears first as a horny protuberance close to the line of section (XXII. 47), which extends backwards into the base of the process, and forwards or upwards into the two hooks. It is also worthy of notice, that generally a greater or less number of solid oval nucleoli and short rod-like bodies make their appearance within the homogeneous substance of the nucleus. The *Opalina Lumbrici* of Dujardin is no other than the animalcule described, although its characters are incorrectly represented by that author, who, from his figure, has evidently seen a specimen which has very recently completed the act of self-fission and not yet reacquired its rounded posterior extremity. The dark stripe shown at the fore part, and supposed to indicate a mouth, represents the uncinate apparatus above described. Stein would call this form of *Opalina* the *O. armata*, and regard it as a further stage of development of his so-called *O. Lumbrici*.

This view is supported by the fact that he has never met with young individuals of *O. armata*; for all the specimens he encountered were of a nearly equal size, and larger than the largest of *O. Lumbrici*, in company with which young beings are very common. Thus *O. armata* attains a length of 1-12‴ to 1-9‴, and *O. Lumbrici* of not more than 1-14‴; even the products of fission of the former are from 1-16‴ to 1-14‴.

"If now it be considered that, excepting the horny process, not the least difference in structure exists between *O. Lumbrici* and *O. armata*, it is rendered very probable that the latter is merely a further stage of development of the former. If this be the case, a subsequent more considerable metamorphosis of *O. armata* may be presumed, when it becomes transferred to a more favourable habitat, as happens when the worm it inhabits becomes the food of some other animal. I have not actually seen *Opalina armata* adhering to the surface of the intestine, for I have always found it amidst the undigested mineral and organic fragments which fill the alimentary canal of the earth-worm. Hence it is more likely that the adhesive organ is destined to subsequently fix the *Opalina* in a more permanent manner."

The long pulsating vessel seen in *Opalina Planariarum* and in *O. uncinata* deserves particular notice, by reason of its peculiarity. Stein has described it in the first-named species, where it extends the entire length of the animalcule, as bounded by a definite, delicate, structureless membrane, and to be without the outlets Schultze imagined. It contains a clear liquid like water, which, by its rhythmical movements, it forces to and fro within it. On killing the animal with alcohol, the walls of the vessel are rendered very evident. It becomes divided through the centre in the act of self-fission, and is, in Stein's opinion, not homologous with the contractile vesicles of the Ciliata.

NUCLEUS. SELF-DIVISION. SUPPOSED EMBRYO.—The nucleus is a very evident organ in all the *Opalinæa*, with the single exception of *O. Ranarum*, in which Stein has sought for it in vain among multitudes of specimens and by the aid of various reagents. In this same exceptional species it is also to be noted that he never witnessed the act of fission, yet Siebold ("*Ueber Monostomum*," Wiegmann's *Archiv*, 1835) described, in an *Opalina* living as a parasite in the intestines of a frog, the existence of a number of small embryos within a cavity of the posterior extremity of the body: whether this animalcule, however, was the *Opalina Ranarum* does not appear; for the peculiar habitat does not by any means prove such to be the case.

A contrast occurs in the *Opalina Branchiarum*, where the nucleus which lies in the axis of the body has the same figure as the entire being, and one-half its dimensions. Even among examples of the same species the position of the nucleus varies exceedingly. Simultaneously with the appearance of a constriction in the general figure, the nucleus shows signs of approaching fission; but ere this is manifested it assumes a central position (whatever may have been its previous one), so that each of the two future segments may acquire an equal section of it. Moreover, it would appear, in some cases at least, that the constriction and scission of the body advance more rapidly on one side than on the other of the animal.

According to Stein, the production recorded by Schultze (*Beiträge zur Natur-*

geschichte der Turbellarien, 1851, p. 67), of a granular germ-mass in *Opalina Planariarum*, at the posterior extremity of the animalcule, was nothing more than the act of fission misconceived. The granular contents of the nucleus (says Stein) are finer or coarser in the animals irrespective of their size; and the supposed germinal masses, as the figure given shows, were merely the segments of the nucleus in process of division, and not illustrations of the ulterior development of that organ into other beings. Schultze witnessed this process but once, in a specimen he named *Opalina polymorpha*, but which was the same as the *O. Planariarum* of Siebold and Stein.

HABITATS, VITAL ENDOWMENTS, &c.—As stated before, the *Opalinæa* are parasites of various animals, the most common of which are frogs, newts, and other Batrachia, earth-worms (*Lumbrici*), some shell-fish, as the *Anodon* and the common muscle (*Mytilus edulis*), and of *Planariæ* and several Entozoa. They are found in the intestines in the earth-worm, in the rectum and bladder in the frog, among the cilia of the tongue of that reptile, or among those of the gills in the shell-fish, &c.

As a memorandum touching the vital properties of *Opalinæa*, we may quote here an experiment made by Kölliker on the vitality and development of the spermatic filaments (*J. M. S.* 1855, p. 298):—"The *Opalinæ* move in a solution of common salt of 1 per cent., and of phosphate of soda of the strength of from 5 to 10 per cent. In a solution of salt of 5 per cent., and of sugar of from 10 to 15 per cent., they shrink up and become quiescent, though reviving upon the addition of water. I have even succeeded in reviving the *Opalinæ* after they had been treated with a solution of common salt in the proportion of one-tenth."

NATURE OF OPALINÆA.—The observations of microscopists in general concur to prove that these simple beings are not independent, but the mere embryonic or transitional phases of other animals. This opinion was put forward by Schultze, and has been seconded by Agassiz, Stein, and others.

Agassiz asserts (Silliman's *American Journal*, 1853) that the deficient link in Steenstrup's history of the succession of alternate generations of *Cercaria*, and its metamorphosis into *Distoma*, is supplied by his discovery that a genuine *Opalina* is hatched from the eggs of *Distoma*. Stein coincides also in considering them metamorphosed into Vermes, and states that Steenstrup has watched the transformation of *Leucophrys anodonta* (Ehr.) into an intestinal worm. He saw first that the cilia vanished, that they fixed themselves, and became by-and-by changed into oval motionless bodies, which continued to grow, and formed an internal space, within which a germinal mass was developed, out of which *Cercaria* originated.

AFFINITIES AND CLASSIFICATION OF OPALINÆA.—Upon this head the first point is to settle what genera and species are to be numbered with the *Opalinæa*. For our part we are disposed to place in this family all Ciliata which are mouthless, and which lead a parasitic life. As already noted, the absence of a mouth is indicative of an embryonic character, an indication strengthened, if not confirmed, by observation; consequently this group of beings is at best but provisional, serving only the purposes of definition and nomenclature, until science shall be enabled to indicate the particular animals into whose cycle of life they severally enter.

Furthermore, we have seen that some reputed species are, in all probability, only different stages of existence of the same *Opalina*,—for instance, the *O. armata* a more adult state of *O. Lumbrici*. And, again, the structural differences between *O. uncinata* and *O. Planariarum* (consisting in the possession of a singular pulsating vessel) and the rest of the group are so striking, that they can scarcely be rightly included in one genus.

On turning to the systematic descriptions of various writers, we find much discrepancy in detail, and much difference in opinion, respecting both the species to be counted among *Opalinæa* and their generic distribution.

The family '*Leucophryens*' of Dujardin, and the *Cobalina* of Perty, severally include most of the species which we would reckon as *Opalinæa*. These, in Ehrenberg's system, were scattered through several genera,—the majority, however, being comprised in his genus *Bursaria*. Stein points out three principal modifications of form, but is not prepared to constitute them into genera.

In the classification adopted by the three first-named writers, the *Opalinæa* were accounted ordinary Ciliated Protozoa. Perty and Dujardin so far recognized their peculiarities as to erect them into a distinct family. Siebold went further, and, on account of the absence of a mouth, placed them, with *Astasiæa* and *Peridiniæa*, among the Astoma. We coincide with Siebold in thus more completely separating them from the stomatodous Ciliata than the other authors named, but at the same time look upon them as more nearly allied with Ciliata than with either *Peridiniæa* or *Astasiæa*, and consequently prefer to treat the *Opalinæa* as a subgroup of those Protozoa.

Neither the intimate structure, nor the developmental history of the *Opalinæa*, is sufficiently well understood for them to be arranged in well-defined genera; nevertheless, as both Dujardin and Perty have each essayed a systematic distribution, it behoves us to set their schemes before the reader.

Dujardin divides the *Leucophryens* into three genera, viz. *Spathidium*, *Leucophrys*, and *Opalina*. Besides these, he has other mouthless genera in his family *Plœsconiens*, viz. *Diophrys* and *Coccudina*, marine but not parasitic animalcules; also a genus *Trochilia* without distinct mouth, also marine in habit, located in the family *Erviliens*; and last, the genus *Plagiotoma*, among the *Bursariens*, parasitic in habit, and supposed to have a mouth situated at the bottom of a fossa, but which contained no foreign matters, and could not be fed artificially with colouring matter. Of these genera *Coccudina*, *Diophrys*, and *Trochilia* are imperfectly known, particularly the two last, and the absence of a mouth cannot be predicated of them with any certainty,—whilst of the last named (*Plagiotoma*) the balance of evidence is against the existence of a mouth, and, as we shall see, this genus is a member of Perty's family *Cobalina*, and has, moreover, in Stein's opinion, no claim to rank as a distinct genus.

The parasitic family *Cobalina*, Perty, comprises the genera *Alastor*, *Plagiotoma*, *Leucophrys*, and *Opalina*. The characters of these several genera, placed by observers among the *Opalinæa*, or some parallel group, together with their mutual relations and differences, will be fully treated of in the systematic section of this work.

FAMILY II.—PERIDINIÆA.

(Plate X. 224–226; XXXI. 16–23.)

This family, in Ehrenberg's classification, comprehended four genera, viz. *Chætotyphla*, *Chætoglena*, *Peridinium*, and *Glenodinium*; but, as Dujardin rightly judged, the two first genera belong rather to the *Cryptomonadina*, by being destitute of the ciliary furrow, the leading characteristic of the *Peridiniæa*. Our description will therefore particularly apply to the two other genera, *Peridinium* and *Glenodinium*.

The beings under consideration have received little attention from naturalists, and are still imperfectly understood. Indeed, we feel that no sufficient data are at hand whereon to ground an opinion relative to their true position, nature, and affinities. We place them here as a supplementary group of

Ciliated Protozoa, first, because of their wreath or general clothing of cilia—a phenomenon seen among none of the Phytozoa or Flagellata, which have never more than one or two, or, rarely, four filaments or flabella; and secondly, because every author who has described them treats them as animalcules. Perty, although recognizing them as animals, nevertheless groups them with his Phytozoidia, probably owing to their bizarre form and to the characteristic internal organization of Ciliata not being perceptible. Siebold, on the contrary, places them, together with *Euglenæa* and *Opalinæa*, among the astomatous or mouthless Protozoa.

Ehrenberg's description of the *Peridiniæa* is as follows:—The animalcules of this family are polygastric, but have no alimentary canal; the mouth is usually found in a depression near the middle, and from its vicinity a delicate filament (proboscis) is given off in three of the genera. They are clothed with a shell or lorica, having a transverse furrow or zone occupied with a row of vibratile cilia; and besides this wreath, several species have also fine setæ or cilia scattered over them. In *Peridinium acuminatum*, *P. fulvum*, and *P.* (*Ceratium*) *cornutum* the digestive sacs are visible without recourse to artificial means; but in *P. Pulvisculus* and *P. cinctum* those organs can be demonstrated only by the use of coloured food, chiefly because they are hidden by the clusters of ova, to which the colour of the animalcules is due. This is commonly red, yellow, or brown, and rarely green. In *Peridinium Tripos* and *P. Fusus* a seminal gland (nucleus) is visible, and in *Chætoglena* and *Glenodinium* a red eye-speck. Longitudinal self-division has been observed in *P. Pulvisculus* and *P. Fusus*.

Dujardin, unable to accept these views of their organization, described the '*Peridiniens*' as "animals without known internal organs, enveloped by a definite resistant membranous lorica, which sends off a flagelliform filament, and has, in addition, one or more furrows beset with vibratile cilia. The lorica would appear to have no orifice, since foreign particles and colouring matters cannot enter it. . . . The members of this family are distinguished from *Thecamonadina* by the ciliated furrow or furrows."

Further, Dujardin ignored the red stigma as a generic distinction, and in this is followed by Perty. Ehrenberg created a subgenus of *Peridinium* for those species which have the lorica prolonged into horn-like processes, under the name of *Ceratium*. Both Dujardin and Perty retain this appellation, but would elevate the group comprehended under it to the rank of a genus.

Let us now proceed with a *résumé* of the facts at present received respecting the organization and habits of the *Peridiniæa*.

The lorica is double, consisting of an outer, more or less firm, non-contractile layer, and an inner, homogeneous, hyaline membrane: usually a space occurs between the two coats; but in *Glenodinium* they are in close apposition—a double contour, however, being perceptible. The inner layer may be taken to represent the primordial utricle; it immediately envelopes the contents, which consist of a homogeneous protoplasm, enclosing within itself numerous globules, granules, and vesicles. In the case of the smallest *Peridiniæa*, such as *P. Pulvisculus*, *P. monadicum*, and *P. Corpusculum*, the distinctness of envelope from contents ceases, and when in a dying condition the whole figure undergoes a great variety of changes—a fact indicating a less perfect development of the lorica—and there is a rapid breaking up of the contents. In the larger species the outer tunic is more elaborated, and either displays a minute cellular or reticulate structure, or appears quite smooth and structureless, although firm and resistant (as in *Glenodinium cinctum*). A cellular lorica occurs in *Ceratium*, and also in various *Peridinia*, which Perty separates from the rest, under the name of *Glenodinium*, by reason of this structure. This external tunic is decomposable, although it resists destruction much longer than the contained matters; and it is especially after a certain amount of change has proceeded, that its delicate retiform structure is more distinctly exhibited.

The figure of *Peridiniæa* is very various and bizarre: the simplest is that of a spheroid divided into two segments, equal or unequal in size, by a transverse ciliated furrow or zone. In some instances one side is flatter and concave, and, according to Perty, presents a wide opening, or elongated fissure (XXXI. 16), from which the filament may sometimes be seen to proceed. Moreover, besides the transverse furrow, a second is seen in some species to proceed from it at right angles, as far as the vertex of the anterior half,—as, for example, in Dr. Allman's species *Peridinium uberrimum* (XXXI. 16, 18), and in *P. fuscum* and *P. oculatum* (*Glenodinium cinctum*, Ehr.). Indeed, in *Glenodinium apiculatum* Ehrenberg describes several subsidiary, shallower, hispid furrows branching over the surface (X. 224-226), and in *G. tabulatum* a series of non-hispid lines or ridges. These last two forms recall in general features the pollen-cells or grains of the higher plants, and may, indeed, from the deficiency of a locomotive filament, and from other exceptional characters, be considered doubtful members of the family *Peridiniæa*. An inequality of the two segments, as separated by the ciliary zone, is seen in *Peridinium Corpusculum* and *P. monadicum*, and in a less degree in *P. oculatum* (*Glenodinium cinctum*). The figure, however, is very curiously and materially altered by the production of tapering or horn-like processes, of a large diameter and great length relatively to the principal portion or body of the organism. These processes differ in number in different species, and give rise to very bizarre forms, departing widely from those of any Phytozoa or from any other ciliated Protozoa. The number of horns in *Ceratium Fusus* is two, and, being in the same line, produce the spindle-shaped figure of the entire being (X. 222, 223). In *C. furca* two occur in front and one of larger dimensions behind; the same is seen in *P. Tripos* (X. 219, 220), in which, however, the two anterior processes are curved,—whilst *P. cornutum* (*Ceratium Hirundinella*) has from two to three posteriorly, and one, usually curved, anteriorly. In *Ceratium Michaelis* (X. 221), again, we see three short processes project from the posterior half; and, lastly, in *C. macroceras* (Perty) three are represented behind, of which the central is much the longest and straightest, and in front one still longer but rather curved. The length of the horns compared with the body of the *Ceratia* affords, however, no specific character, inasmuch as it varies according to age and probably also other conditions. The vibratile cilia are usually confined to the groove surrounding the lorica, and to the direct continuations from it. Nevertheless Dr. Allman discovers in *P. uberrimum* the whole surface sparsely covered with them; and Ehrenberg mentions the supplementary furrows of *Glenodinium apiculatum* as occupied with hispid hairs (X. 224–226). The locomotive filament, which Ehrenberg failed in seeing in all even of his genus *Peridinium*, is usually of great length and tenuity, and, according to the great Berlin micrographer, proceeds from the neighbourhood of the mouth which he believed he detected in *Peridinium Fusus* in a hollow near the middle of the animalcule. Allman more definitely points out its situation as being near the junction of the transverse and vertical furrows in the species he has described (XXXI. 16). Lastly, Perty states that *Ceratium Hirundinella* (*C. cornutum*, Ehr.), when swimming, stretches out the filament as if stiff, and that, although 2½ times longer than the body, it may be easily overlooked, on account of its active swinging movement. It is apparently a production of the protoplasm, protruded externally through an aperture in the investing tunics. Opinion is divided respecting the existence of a mouth. Ehrenberg represented one, and also the possible admission of coloured food, but was contradicted by Dujardin, who denied both. Siebold reckons *Peridiniæa* among mouthless Infusoria (*Astoma*). Perty mentions the fossa in the shell, but no aperture; and Allman remains silent on the matter. On the other hand, Lachmann admits its presence, and thus discusses the mode of reception of food (*A.N.H.* 1857, vol. xix. p. 220):—"From the point of insertion of the flagellum, on one side the large notch, in the upper part of the row of cilia, a clear canal passes into the body of the animal, and dilates at the extremity to form a cavity of variable diameter. The flagellum is often seen to contract rapidly into a spiral form, and apparently disappear; and not unfrequently we may then succeed in perceiving that it is jerked back into the above-mentioned cavity, from which it soon returns into its previous position. Now it certainly appears worth while to see whether small particles of food are not carried into the cavity by this jerking in of the flagellum."

CONTENTS.—These may be divided, as in the *Euglenæ*, into minute shapeless molecules, and globular corpuscles and vesicles with red stigma and nucleus. Sometimes the corpuscles are green, and resemble chlorophyll, but more frequently they are red, yellow, or brown, or intermixtures of those colours. In the earliest stages, indeed, colour is absent, and, just as in *Euglenæa*, only minute moleculæ are found interspersed in the colourless protoplasm. Moreover, when a colour appears, it may not simply become more intense or darker by age, but change to another tint belonging to the same series of colours.

In younger specimens again, the contents more completely occupy the entire being, whilst frequently in old, and more especially in specimens withering or dying, they become contracted into a ball, placed either in the centre or more or less to one side (excentric). A swelling out of the external tunic, the disappearance of the red stigma, the vibratile cilia, and the filament accompany this shrinking of the cell-contents. The retrograde change in the contents is further manifested by the appearance of a large vesicle about the centre, or of several dispersed smaller ones at that or in other parts. Some at least of these vesicles are merely oil-drops, which, as Braun shows in his essay on Rejuvenescence, are the usual concomitants of a process of destructive assimilation. After the destruction of the cell-contents, the firm lorica remains like an empty shell, boldly displaying its sculpturing, and in many instances also a curved, apparently internal, stripe about the middle or to the right of it, which Perty presumes to be either the line of attachment of the contents or a fold.

Among more constant structures, Dr. Allman describes a central nucleus—the organ probably alluded to by Ehrenberg under the name of an oval seminal gland, in *Peridinium Tripos* and *P. Fusus*. Allman describes the nucleus to be of an irregular oval form, quite colourless, and marked on the surface with curved striæ (XXXI. 20); under pressure the envelope gives way, and the nucleus escapes with the other contents. A contractile vesicle has not hitherto been discovered. One or more large clear vacuoles may originate in the internal substance; but such have not the pulsating power of definite vesicles.

The red speck or stigma (XXXI. 16, 17) has no pretensions to the nature of a visual organ. It is not always present even in examples of the same species; or it is multiplied; and it is known also to disappear with advancing age. Again, Perty recounts the fact of the diffusion of the red colour of the speck throughout the whole contents, at times leaving a narrow external ring which retains its green colour. This phenomenon was witnessed in a specimen of *Glenodinium cinctum*. In young individuals of *Peridinium tabulatum*, which are of a light-green colour and translucent, there is no trace of a red speck; yet Perty met with a collection of these beings of apparently smaller size than usual, yellow in colour, and not, like older animalcules, greenish-brown or brown, which had from 10 to 12 red vesicles or globules about the middle of the anterior segment. Still the general rule is that in very young individuals no stigma is present. The inconstancy of the presence of the red speck, even in mature specimens, its absence in very young, its disappearance in old ones, and the many irregularities, not only in its occurrence but also in size and number, are facts which sufficiently prove its worthlessness as a generic or even as a specific distinction, and which declare against its assumed function of a visual organ in this as in other families of Protozoa.

REPRODUCTION.—Longitudinal fission has been seen to take place in several species. Self-division, says Perty, presents many peculiarities among the *Peridiniæa*. In *Ceratium Hirundinella*, fission is longitudinal; it commences anteriorly close to and on the left side of the great horn (as the animalcule is viewed from above), and advances towards the posterior extremity. The process is not confined to the large specimens, but is equally enjoyed by the small.

During the act of fission in *Peridinium Pulvisculus*, Perty noticed that before its completion the newly-formed segment continued to augment in size until it surpassed the original being, which underwent no enlargement.

Dr. Allman noticed, in the species he examined (*J. M. S.* 1854, p. 25), that spontaneous division took place "parallel to the annular furrow" (XXXI. 18), *i. e.* therefore transversely, "and in the unfurrowed hemisphere." He also remarked the important fact, that this process appears to be invariably preceded by a division of the nucleus; and he had succeeded in isolating nuclei presenting almost every stage of transverse fission. But besides their reproduction by fission, Perty adopts Ehrenberg's views and insists on their development from ova or ovules, which present themselves in the form of brown or green corpuscles in the interior. *Peridinium tabulatum* is often seen to be full of such, elliptic in figure, and as much as 1-150‴ in length, and which can be expelled by pressure from the animalcule. In *P. Pulvisculus* Perty met with specimens from 1-400‴ which were aggregated together in masses, and moved together. In *P. Corpusculum*, he asserts, development from ovules may be directly observed; and he gives figures of ovules set free, and of the young generated from them, which would seem the same structures with the addition of a cell-wall. The ovules, too, are large and very evident in *Ceratium cornutum*; and he regards the small brown organisms which may be found in company with mature individuals at various times of the year, as the primitive stage of generation of those ova before acquiring the perfect figure of *Ceratium*. In some specimens, indeed, he remarked the long filament peculiar to the species, and a red stigma in the posterior segment. The smallest examples measured 1-200‴, and were at first elliptic; from this they changed to reniform, and became distinguished into an anterior and a posterior half. Their movement was rotatory or spiral, and quicker than in old individuals. On one occasion he saw small examples of *Ceratium Hirundinella* only 1-25‴, of the same figure as the large specimens, but completely colourless; at another time he encountered pale brownish-green individuals, with a beautiful red stigma, and the posterior lateral horns scarcely developed,—whilst in one instance the anterior cornu was completely formed, and the posterior extremity rounded. These examples, he observes, appear to be different structural phases through which the products generated from the ovules have to pass.

The reproduction by ovules or internal germs has its parallel in *Euglenæa*; and, like as in this group, so in the family *Peridiniæa* a quiescent, resting, or "still" stage appears to occur. Dr. Allman has put forward this fact most clearly. He writes (*J. M. S.* 1854, p. 24)—"Before death, and also when passing from a motile to a quiescent state, most likely preparatory to undergoing some important developmental change, the contents contract towards the centre; and then an external transparent and perfectly colourless vesicle becomes visible, while the flagellum and cilia disappear. The contracted contents present a very definite and general spherical boundary, and are evidently included in a distinct cell"—the primordial utricle. On a subsequent examination of the pond in which the species examined occurred in prodigious quantity, he found "immense masses" of the *Peridinium* "towards the bottom, where they appeared quite healthy, though presenting the condition described above as characterizing the quiescent state of the animalcule."

Our imperfect information respecting the organization of the *Peridiniæa* renders any arguments concerning their nature unsatisfactory and inconclusive. Perty, to whom we owe most of our knowledge respecting these creatures, agrees with Ehrenberg in assigning them an animal nature; and we gather from the few remarks Dr. Allman has made, that this opinion has also the advantage of his support. Dujardin, we may add, treated the *Peridiniæa* as animalcules. Of the opposite opinion, viz. that they are members of the vegetable kingdom, we know of no advocates, although some facts, such as the apparent absence of the known internal structure of the Ciliated Protozoa, the non-contractility of their bodies, the character, colour, and changes of their contents, might be adduced in its favour. However, the force of those presumed facts will be much lessened by the consideration that the internal organization of the Ciliata may yet be discovered in these organisms when they receive their due share of attention from microscopists, that even the absence of a mouth and rudimentary digestive tube would not absolutely exclude them from the animal kingdom; and that in the form and character of their ciliary armature they present an animal much more than a vegetable type.

Of their VITAL ENDOWMENTS, we may state that some swim with considerable activity by means of their flagellum, aided, no doubt, by their ciliary wreath, which probably gives the oscillating and rolling character to their movements.

They are inhabitants both of salt and of still fresh water, among aquatic plants, but not of infusions; and they disappear from water when long kept. Most of the genus *Peridinium* are marine. They may occur in such enormous multitudes as to colour the pond or other collection of water in which they have accumulated. Of this phenomenon Dr. Allman mentions an example in which his *Peridinium uberrimum* was so abundant in the ponds of Phœnix Park, Dublin, as to colour the water brown:—"This colour was sometimes uniformly diffused through the water; at other times it appeared as dense clouds varying from a few square yards to upwards of a hundred in extent." This was in June; in July "the coloration of the ponds had much increased in intensity.... The colour in some parts was of so deep a brown, that a white disk half an inch in diameter became invisible when plunged to a depth of 3 to 6 inches, while a copious exit stream, which constantly flowed away from one of the ponds, presented the same deep-brown tint."

The most remarkable vital phenomenon presented by the *Peridiniæa*, and which is particularly common in them as a family, is that of phosphorescence, which is possessed in a high degree by several of the marine species, having a yellow or yellow-brown colour. In nine phosphorescent drops of sea-water from near Kiel, taken up one after another by Ehrenberg, nothing save a single individual of *Peridinium* (*Ceratium*) *Tripos* was discoverable. Besides this species, the following other *Ceratia* are phosphorescent, viz. *Ceratium Fusus*, *C. acuminatum*, *C. Michaelis*, and *C. Furca*.

Ehrenberg has reported the occurrence of fossil *Peridiniæa*; but the organisms so considered are peculiar in having a silicious shell, which renders their alliance to this family somewhat doubtful. They are met with in chalk, the only secondary stratum, and here in the substance of flints; but they also occur in strata of later formation. Their presence in flints renders it, indeed, supposable that their silicious constitution is an ulterior result of the infiltration of silex in a state of solution into the texture of their previously membranous envelope. They are found in company with fossil *Pyxidicula* and *Xanthidia*. Ehrenberg described two fossil species under the name of *Ceratium pyrophorum* and *C. Delitiense.*

CILIATA.

Group B.—Stomatoda.

(Illustrated by Plates XXIV.-XXXI.)

The animalcules whose general history we have now to write are, as before mentioned, comprehended for the most part in the families *Dinobryina, Vorticellina, Ophrydina, Enchelia, Colepina, Trachelina, Ophryocercina, Aspidiscina, Kolpodea, Oxytrichina,* and *Euplota,* as instituted by Ehrenberg, with the removal of the *Opalinæa* from the *Trachelina,* and of the *Acinetina* and *Actinophryina* from the *Enchelia.*

The descriptions of the beings composing these several families, as furnished by Ehrenberg, are so tinged by his peculiar views of organization as to mar their utility; and therefore, for precision and accuracy of detail, we have to rely in great measure on the observations made within the last few years, chiefly by German naturalists. Notwithstanding the persevering industry with which these scientific men have pursued their inquiries, many genera yet remain almost unknown, or little understood, in respect to their structure, whether internal or external.

The Ciliated Stomatoda, or as we shall more briefly style them the Ciliata, are microscopical animals having a definite limiting membrane or external tunic covered more or less completely with vibratile cilia, by which they swim; and when it is indurated, as not unfrequently happens, it is further furnished with bristles or other tegumentary appendages, by which they are capable of crawling or leaping. They all possess a more or less distinct mouth, which opens into an œsophagus or gullet, continued to a variable extent into the interior as a digestive or alimentary tube, but ending abruptly by an open extremity. In many genera a discharging orifice or anus is perceptible; and in all there are a nucleus and one or more contractile vesicles. They propagate by self-division, by gemmation, and by internal germs or embryos, with a greater or less degree of metamorphosis, and they undergo the encysting process: the act of gemmation appears limited to a few genera; but self-fission and embryonic development may be predicated as general phenomena.

Dimensions.—In dimensions all the Ciliata are microscopical; for if some, such as *Spirostomum, Stentor, Opercularia, Zoothamnium, Vaginicola,* and other genera of *Volvocina* and *Ophrydina* are visible to the naked eye as minute specks or globules, they are far beyond its ken for any purposes of investigation, and are therefore essentially objects for the microscope. Yet amid these hosts of equally microscopic beings, the range in point of size is actually as great as that between the dog and the elephant among animals cognizant to our ordinary observation. Even among members of the same genus, and, indeed, of the same species, their dimensions may vary within limits extremely wide. To quote a few examples: *Spirostomum ambiguum* (Ehr.) has a length of $\frac{1}{12}$th of an inch; the branching polyparies in *Epistylis* and *Opercularia* reach $\frac{1}{8}$th in height, those of *Zoothamnium* $\frac{1}{4}$th, whilst many stalked *Vorticellæ* extend themselves to $\frac{1}{12}$th in length. *Paramecia* are mentioned by Ehrenberg from $\frac{1}{90}$th to $\frac{1}{1150}$th in length; and specimens of the same species of *Vorticella*, viz. *V. microstoma*, are described to vary in size between $\frac{1}{2300}$th and $\frac{1}{240}$th. Stein has also noticed examples of *Chilodon Cucullulus* from $\frac{1}{240}$th to $\frac{1}{1200}$th. A most surprising magnitude is attained by the polypoid masses of *Ophrydium versatile*, which range between mere microscopic globules and aggregated masses the size of the fist or even of the head of a man.

FIGURE.—In figure the Ciliata exhibit an immense variety, but have a rounded outline in all instances. The prevailing figure is oval or oblong; but some taper much at one or both ends, and acquire a spindle-, or a flask-, or a club-shaped aspect, whilst others, as the *Vorticellina* (XXVII. 1, 2, 4, 16; XXX. 1, 9, 11), present a bell-shaped or campanulate outline, and others again, as *Spirostomum* (XXIV. 298), an elongate ribbon- or band-like one. However, the best idea of the manifold forms can be gathered by inspecting the subjoined plates of the Ciliated Protozoa, which render verbal description unnecessary.

The figure is determinate and constant under like phases of existence for each species, although liable in the majority to very great changes by the contraction and movements of the animalcules, by their contact with more solid bodies, and by the introduction of food. These changes are proportionate to the elasticity of the integument and to the contractile power of the contents; and hence, in several with firm integument, they are very limited, or not possible.

The figure is also much modified by the processes of multiplication and of reproduction. The act of fission materially modifies it; gemmation does so to a less extent; but the most remarkable change is caused by the encysting-process, which is generally a prelude to the peculiar set of phenomena attending the reproduction by germs or embryos, and, according to Stein's views, would seem to terminate in actual metamorphosis or transformation of the beings concerned. Indeed the Ciliata in general appear to pass through a cycle of changes, each of these entailing a distinct figure; in other words, in the history of each ciliated Infusorium, there are several phases of existence, differing from one another in form and other particulars. The history of an animalcule, therefore, is comprehended in that of no one form or phase, but in that of every one it normally assumes; nevertheless it is necessary to fix upon one phase, either as the most important or the most perfect, and to characterize and name it, just as is done in the case of insects, which are described in their most developed or "imago" condition.

Another point to be remembered is, that the figure of a specimen appears different in most cases, according to the aspect in which it is viewed; and, again, there is often much diversity in shape between young beings and those arrived at maturity. Perty has applied the term '*metabolia*' to express the changes of figure animalcules may assume. The figure is extremely varied in *Lacrymaria* by its movements, and chiefly by the lengthening or shortening of its elongated anterior portion or neck. This variability of form struck Baker and other old observers so forcibly, that they applied the term *Proteus* to designate the animalcule (XXIV. 274, 275). *Trachelocerca* (XXIV. 317–319) and *Phialina* have a similar power of varying their outline; and all three genera are further remarkable by the manner in which their surface can be thrown into transverse or even intersecting folds or plaits.

The influence of food when swallowed in modifying the figure, Ehrenberg particularly illustrated in his *Enchelys Farcimen* (XXVIII. group 64). This animalcule devours others nearly as large as itself, and, to effect this, widely dilates its mouth, and so becomes shorter and broader; and as during the operation it continues to swim about, its appearance with the half-swallowed being is very curious. Again, when engulfed the anterior portion contracts, whilst the posterior becomes dilated, giving the *Enchelys* a flask-shaped outline.

In descriptions of the Ciliata, authors have used various terms, applied to the segments or members of higher animals, to designate varieties in the form and in the mutual relation and position of their parts. The application of many of these terms to the Protozoa is indeed very arbitrary and fanciful; and it is only from the absence of better that we continue to employ them. The end of the body which advances foremost in swimming, and at which or near to which the mouth is ordinarily placed, is called the head, and often has an additional claim to the appellation by its construction as a segment distinguished by some points of structure from the rest of the body. The opposite portion of the animal constitutes, when tapering or provided with some sort of process, the tail, but is more generally spoken of, especially when not distinguishable as a segment, as the posterior or caudal extremity.

A '*dorsum*' or back, and a '*venter*' or abdominal surface, are usually described, but are not readily determinable in all genera, as, for instance, in the *Vorticellina* and *Ophrydina*. To distinguish the one surface from the other, regard must be had to the position of the mouth (which indicates the abdominal surface), to that of the locomotive cilia and other processes, and to the mode of progression. But, after all, the distinction will oftentimes be arbitrary, and in consequence the description of a right and a left side frequently so too. It is a general character of the Ciliata, that they are asymmetrical, *i. e.* not formed of two equal and similar halves. An exception to this rule exists in *Coleps* (XXIV. 284) and in the *Ichthydina* (XXXI. 28–30), which in Ehrenberg's system were included with the *Rotatoria*. Where, although symmetry is not visible, a right and a left side are distinguishable, such Infusoria are called 'bilateral,'—*e. g.* the *Oxytrichina* (XXVIII. 10), *Paramecium* (XXIX. 25–30), *Chilodon* (XXIX. 48).

Of minuter modifications in the figure of Protozoa, a large number have found names which will be best understood in the special structural details of particular animalcules. However, to mention some here used by Ehrenberg, we may cite the frontal region or forehead—the obtuse or truncate part of the head above the mouth; the lips—projections above and below the mouth, when this aperture is situated in a fissure; the tongue or palate, usually a process in the oral fissure; the rotary or ciliary disk, seen as a ciliated projectile process above the margin of the anterior extremity of the *Vorticellina* (XXX. 1, 2, 9, 11, 14). In several genera the anterior portion of the body is much produced, and looks like a long tubular neck or a trunk, and hence is called frequently by Ehrenberg proboscis,—*e. g.* in the genera *Lacrymaria* (XXIV. 274, 275), *Trachelius* (XXIV. 287–289), *Amphileptus*, and *Trachelocerca* (XXIV. 317–320). This term proboscis we have already seen used to designate the long locomotive filaments or flabella of Phytozoa, totally different processes from those called by the same name in the Ciliata just enumerated. Its use for one or the other should be set aside; and although at the best it conveys a very erroneous impression—for no such thing as a proboscis or trunk, in the proper meaning of the word, has an existence in any of the Protozoa—its application to these is less objectionable than to the Phytozoa. In *Uroleptus* (XXV. 333) the posterior extremity is abruptly elongated, and forms, according to the description of the same distinguished naturalist, a tail.

Consistence.—The Ciliata are composed principally of a very soft, almost mucilaginous matter, which has been well named '*sarcode*,' since, like the flesh or muscular tissue of higher animals, it seems to present an inherent contractility and elasticity, and is the active agent in the movements of their bodies. It is hyaline, transparent, and colourless; but its refractive power is not much greater than water, which is essential to the exhibition and continuance of its properties, for when this fails the homogeneous mass of sarcode breaks up into minute globular portions, which disperse themselves on every side. This disruptive process has received the appropriate name, from Dujardin, of '*diffluence*.'

Ecker states this self-same sarcode to be the common contractile element of all the lowest forms of animal life—for instance, of the Polypes. The particles set free by '*diffluence*,' he also represents to be contractile, and to assume *Amœba*-like movements; but this, according to Cohn and Stein, is an error, inasmuch as they are simply elastic. Cohn also adds that the variable movements of the sarcode-particles of *Hydra* are merely a physical phenomenon due to endosmosis. The process of diffluence, whether from external injurious conditions or damage, or from noxious matters received within, varies so much in rapidity, that Cohn (*Zeitschr.* 1851, iii. p. 267) concludes that it must indicate some variations in its composition and structure in different animalcules. For instance, he says, *Stentor cœruleus* bursts; and its contents break down by diffluence as rapidly as sugar in water, streaming out from the rest until the funnel-like pharynx only is left behind. On the contrary, in other animalcules, *e. g. Paramecium Aurelia*, the sarcode exudes through the surface at all points, and swims away, leaving a vacuolated or areolated interior. Again, *Loxodes* breaks up into fragments of a considerable size, which escape through lacerations of the surface.

INTEGUMENT. MARKINGS ON THE SURFACE. CONDENSED INTEGUMENT OR LORICA. APPENDAGES OF INTEGUMENT. CILIA. SPINES. EXTERNAL SHEATHS. —Ehrenberg described his *Polygastrica* as in all cases defended, and their figure defined, by an integument or skin,—a statement as generally contradicted by Dujardin, though now confirmed (in the case of all the true Ciliated Protozoa) by the researches of numerous later naturalists. The means resorted to for its demonstration, where not otherwise evident, consist in the application of chemical agents—for example, of acetic acid, of tincture of iodine, and of diluted alcohol, all which operate in a different manner upon the integument and on the contents of the body, most frequently causing a separation of the two by corrugating the latter, and, it may be, colouring it at the same time.

Perty could not convince himself of the existence of an epidermis, although he believed the external surface to be modified so far as to render it more resistant, or in fact to form what Mr. Carter calls a pellicle; at the same time he attributed marks or lines visible on the surface to fat- or other corpuscles subjacent to it. "The pellicula," Mr. Carter says, "is a structureless product, which hardens after secretion; and the inference is that there is a layer below specially organized for its formation," and that it is not secreted by the lamina known as the "cortical layer" or the "diaphane."

On the other hand Meyen, Siebold, Kölliker, Frey, and Leuckart concur in describing a distinct enveloping delicate membrane, which Frey thought evidenced both by the manner in which an animalcule ruptures under pressure and gives vent to the soft contents, and by the appearance of little shreds he noticed on the torn edges of a *Stentor*. A more direct demonstration was afforded by Cohn, who resorted to chemical reagents for the purpose.

This excellent observer experimented with several of the larger Ciliata, but for illustration referred chiefly to *Loxodes* (*Paramecium*) *Bursaria*. Stein argues that the animalcule so described by Cohn was not a *Loxodes*, but a *Paramecium*, since all its cilia were of equal length, a feature peculiar to this genus (Stein, *op. cit.* p. 239). On adding a little alcohol to a drop of water containing specimens of this animalcule, death ensued; but before this happened, a delicate membrane was seen to elevate itself at parts of the surface, producing a vesicular appearance, and accompanied by a shrinking of the contained matters; while these changes proceeded, several contiguous vesicles would run into one, and thus strip more or less completely the subjacent tissue, until, by the prolonged action of the alcohol, a central shrunken mass appeared, surrounded by a loose membrane, adherent to it only at the spot where the mouth was continued inwards as a pharynx. This membrane, so demonstrated, is homogeneous and transparent, but not entirely structureless; for close observation reveals, over its entire surface, two series of spirally-disposed, delicate, and closely-approximated lines, which so intersect one another as to produce a miniature diamond pattern (XXIX. 26). Further, the notched or serrated appearance of the periphery (XXIX. 28, 29, 30) shows that these lines are actually folds or furrows, and that each little diamond may be represented as a minute four-sided pyramid bearing a cilium at its summit.

By pursuing a similar plan of investigation, a separable integument has been demonstrated in many Ciliata. For instance, Stein described such a covering in the several genera he subjected to observation, and proves its existence also after the process of encysting has taken place. On adding dilute acetic acid to the *Vorticellina*—for example, to specimens of *Epistylis* or *Opercularia*—the contents shrink into a denser mass, and in so doing detach themselves from the integument, which is then rendered evident as a transparent, structureless, homogeneous, and smooth membrane, having a clear, sharp outline. When tincture of iodine is applied, the integument remains uncoloured, whilst the contents acquire a golden-yellow tint. A solution of sugar, and afterwards a drop of concentrated sulphuric acid, being used, causes the contents to swell up and to assume a rose-red colour, the external wall continuing uncoloured.

Respecting the chemical constitution of the membrane of *Loxodes*, Cohn informs us it is soluble neither in sulphuric acid nor in potassa, whilst the contents are dissolved and dispersed by the latter. From this reaction he concludes that the cuticle is not a proteine compound, like animal membrane in general, but the substance called *chitine*, and therefore in this respect similar to the cuticle of plants. In *Paramecium*, he adds, an integument having the same sort of markings and a similar chemical reaction exists, and that, without doubt, all the species described by Dujardin as having a reticulated envelope, in his families 'Bursariens' and 'Parameciens,' have a like structure. Moreover, this skin has its special characters in different genera, as is illustrated in the above account of *Paramecium Bursaria*, and may be exemplified in other cases. Thus in *Coleps* and *Stentor polymorphus*, the cuticle is so intersected by lines as to leave intermediate four-sided prisms, each of which bears a cilium at its apex, whilst at the intersection of the lines, single long hairs are also seen, similar, says Lachmann (*A. N. H.* 1857, xix. p. 125, in footnote), to the hairs of many *Turbellaria*. Again, *Ophrydium versatile* has its integument thrown into fine, closely-aggregated, annular folds, and into three longitudinal rugæ on one side (XXX. 5), which disappear when the animal shortens itself by contraction (XXX. 6). *Spirochona* (XXX. 17), says Stein (p. 208), has a hyaline, firm, inflexible parchment-like skin, with a distinct double outline, but without any inherent contractility. It is most like the integument of *Euplotes*, but differs apparently in not being capable of falling into folds around the body. It resists the action of acetic acid, which dissolves out the whole of the living contents, and leaves it in an isolated state.

Whilst representing all animalcules to be covered with an integument, Ehrenberg distinguished those enclosed by a firm, more or less unyielding, envelope or sheath, as 'loricated,' in opposition to the rest, which he called 'illoricated.' These terms he has, however, employed in so loose a manner, that they really possess no definite and constant meaning. For example, the sheaths of encased animalcules represented by the *Ophrydina* are designated loricæ, the enclosed animal, although possessing a distinct integument, being considered naked,—while, again, the indurated closely-fitting integument of *Euplotes* and *Coleps* is equally styled a lorica, although so different in character and relations. The term lorica could only, indeed, be legitimately employed either to designate the sheaths of such animalcules as the *Ophrydina*, or the indurated integument of others, as *Coleps*,—to one or the other, but not to both; to the former it is unnecessary, to the latter it is admissible.

The integument of the Ciliata has generally been regarded to be in itself contractile; but it seems that this is an error, and that, in fact, it is simply elastic. As such, its action must be counter to that of the subjacent contractile layer, and be therefore the chief agent in restoring the figure when the contractile force is relaxed; at the same time its elasticity will allow of considerable alterations in form, from contact and pressure of external more rigid objects. To this an exception occurs in the case of those Ciliated Protozoa in which the integument is much hardened, and forms a lorica or shield. This induration may be more or less extensive, so as either to cover the dorsum with a shield-like plate (scutellum), as in *Chlamidodon*, or to entirely surround the animalcule, as in *Coleps*, when it constitutes an "urceolus," open at the ends.

The external envelope, when thus hardened, has developed from it various processes, of a more or less rigid character, which look like spines (setæ) (XXIV. 284, 285), or hooks (uncini) (XXV. 344, 347), or are elongated as styles (XXXVIII. 10; XXV. 350, 351), all which are oftentimes made subservient to the act of locomotion, and less frequently to that of prehension also. It must, however, be admitted that such processes are not confined to genera in which the integument is very appreciably indurated, but occur where it is of softer consistency—for instance, in *Stylonychia* (XXV. 343, 344).

The integument is combustible and also diffluent, even when indurated, just as are the softer contents, although more slowly.

External Sheaths or Cases.—Before quitting the account of the common integument or cuticle immediately investing the body of the Ciliated Protozoa, a description of an homologous membrane, in fact, of a prolongation, deduplication, or process of it, in the form of an external sheath or case about certain fixed species, becomes necessary.

The species so encased are either sessile or have only a short stalk attaching them to the bottom of the case; thus *Vaginicola* (XXVII. 10, 11) is stalkless or nearly so, whilst *Tintinnus* has a more appreciable pedicle: on the other hand the case itself may be stalked, as in *Cothurnia* (XXX. 12–16); where this happens, the stem does not equal the length of the sheath, but is short, solid, and thick, expanding upwards to its attachment with the base of the latter, and frequently thrown into transverse folds and curved (XXX. 12, 15). It is homologous with the rigid stem of *Epistylis*, which it resembles also in chemical characters.

A very remarkable exception to the general rule of the attachment of tunicated *Vorticellina* to the bottom of their case, occurs in the new genus *Lagenophrys*, in which the animalcule is suspended from the narrow aperture of the sheath, so as to leave a more or less considerable space around it (XXX. 29–34). The margin of the head of the animal, *i. e.* the peristom, is beneath the opening of the sheath, which has the further peculiarity of being very narrow and two-lipped (XXX. 29, 32, 34). In one species (*L. nassa*) a cylindrical short tube, with a serrate edge and longitudinally striated, is represented by Stein to project from the opening of the sheath. It is, he adds, separable above into two lips, which close when the animal retracts itself.

It is not very unusual to meet with sheaths occupied by two animalcules, —a circumstance due to the act of self-division (XXVII. 10; XXVIII. 19). In a few instances also, one, two, or more small young individuals lie free within the sheath of the parent, *e. g.* *Lagenophrys* (XXX. 29, 34). The sheath is always a product secreted from the animalcule, and first makes its appearance around its base as a soft, homogeneous, colourless, jelly-like matter. During the process of its formation, the animal preserves a contracted state, which diminishes, however, as the excreted layer advances, and ceases on its completion; and since each genus has a characteristic outline, as well in the contracted as in the expanded condition, the sheath acquires also its special character only. More or less of the posterior extremity is concerned in excreting the formative matter; but this having adhered to the anterior part whilst in a contracted state, becomes drawn forward by the progressive elongation of the entire body, until at length, on full expansion taking place, the connexion is broken and the sheath acquires a free edge. So soon as excreted, the gelatinous layer proceeds to solidify, and simultaneously to contract itself in thickness, so as to form a membrane, which, on its subsequent detachment from the fore part of the animal, forms a loosely-investing case around it. This description of the construction of the sheath applies to all those genera where the animal is fixed at the bottom; but in the instance of *Lagenophrys*, where it is suspended from the constricted orifice of the case by its peristom, some other plan of formation must be presumed, concerning which, however, we have as yet, unfortunately, no direct observation to teach us. In several species, as *Cothurnia imberbis*, the sheath not merely acquires a parchment-like firmness, but also a decided colour—mostly yellow at first, afterwards a rusty red.

Dr. Strethill Wright, of Edinburgh, has kindly sent us some notes on the intimate structure of the sheath of *Lagotia*; and doubtless they hold good to a greater or less extent, so far as they represent general facts, in the case of sheaths of other *Ophrydina*. He writes—"The tube consists of yellowish chitine, lined with a layer of dark-green sarcode of varying thickness (which, I believe, secretes the chitine), and covered externally by a much thinner layer of matter, which appears to be equivalent to the '*colletoderm*' of the *Hydroidæ*." This structure is illustrated by figs. 12 and 13, Pl. XXXI. The following account applies specially to the sheath of *Lagotia* (XXXI. 7, 8, 12, 13), which presents a series of rings, apparently spiral, but, in our opinion, not so. "The lines," says Dr. Wright, "are seen to consist of the remains of the trumpet-shaped mouth, which is partially absorbed as the tube increases its length, but still remains as a slightly-overlapping ridge over the new part of the tube growing within it. The groove thus formed is filled up with the '*colletoderm*.' The spiral character seems to be in some way connected with this mode of growth; but I have not satisfied myself in *what* way." In a subsequent letter he writes—"The chitinous matter of each successive ring is not continuous with that of the rings above and below it; it is only attached to it by the inner lining of sarcode and by its outer covering (XXXI. 12, 13). We have by this condition a provision for the growth of the tube, both in width, length, and thickness, similar to that which occurs in the shell of *Echinus*. Growth in length may be effected by deposition of chitine on the upper and lower edge of each ring, growth in breadth by the gradual unrolling of the spiral, while a continuous deposition of hard matter from the inner lining of sarcode thickens and strengthens the whole tube."

In speaking of the attachment of the sheath, we have mentioned only that by the base, with or without a stalk. But there are a few forms which affix themselves to foreign bodies by one side of their sheath, *e. g. Vaginicola decumbens* (Ehr.) and the genus *Lagenophrys*. In such cases the attached side is flattened, so as to increase the surface in contact.

But, apart from the mode of attachment, the sheaths of different genera vary in figure; and as to size, there is no constant relation between that of the case and that of the enclosed being. The figure of the sheath, even in one and the same species, is subject to modification from age and from surrounding circumstances. Thus, in *Vaginicola crystallina* it is usually cylindrical and truncate (XXVII. 11), but at times it may be bellied posteriorly (XXVII. 10), or, otherwise, have its anterior border expanded and curved outwards, or be narrowed in front, or compressed in one direction. Nevertheless there is usually a general resemblance in figure among individuals of the same species or genus, sufficient to furnish descriptive characters. For example, *Cothurnia imberbis* has commonly a cylindrical sheath, bellied posteriorly and slightly contracted anteriorly (XXX. 15), whilst *C. Sieboldii* is campanulate, and has its anterior half compressed in one direction, and its angles in front prolonged and tapering (XXX. 13, 14). In the genus *Lagenophrys*, when adherent by its flattened side, the sheath appears ovoid or shaped like a bellied oil-jar, with a contracted truncate mouth (XXX. 29, 30). A peculiar form of sheath is presented to us in the genus *Lagotia* (XXVIII. 21, 23), which may be described as retort-shaped, the relative diameter and length of the body and neck differing in different specimens or species. In one species, at least, the neck has the further peculiarity of being thrown into spiral or, otherwise, annular folds or rings (XXXI. 7, 8), the presumed form and origin of which have just been described.

We are further indebted to the discoverer of *Lagotia* for the recognition of a remarkable valvular structure within the tubular sheath of a species of *Vaginicola*, which he in consequence names *Vag. valvata* (XXVIII. 18, 19). Dr. Wright states (*Edin. New Phil. Journ.* April, 1858)—"On examining the valve *in situ*, I found it to consist of a rigid plate imbedded in a thick layer of transparent sarcode (XXVIII. 18 *b*), which latter was continuous at the lower end of the valve with a thin layer of the same substance, lining the whole of the interior, and coating the upper part of the exterior of the tube. The valve was closed by a contractile process passing from its under-surface to the wall of the tube.... I am disposed to consider the whole apparatus to consist of an oval plate of soft sarcode, supported by an included bar or narrow plate of horn or chitine....In some specimens the tube was marked with close transverse or circular striæ."

In *Stentor Mülleri* (XXVIII. 16, 17), we have the curious instance of an animal living indifferently with or without a sheath, and enjoying freedom of movement. Amidst numerous specimens of this species, not a few (says Cohn) may be seen swimming freely about, or, otherwise, attached, enclosed within a roomy ovate sheath, composed of a soft gelatinous substance, and open at one end (XXVIII, 17). The animalcule is fixed by its posterior extremity (apparently converted for the time into a suctorial disk) to the closed end of the sheath; but it is still able to evert its spiral ciliary wreath, and to extend itself beyond the open mouth, or to retract itself in a contracted condition within its interior. Ehrenberg remarked the exudation of a mucous sheath around this animalcule when kept confined for some time for observation within small glass tubes, but mistook it for a sort of morbid act preparatory to death. Cohn, on the contrary, has shown (*Zeitschr.* 1853, iv. p. 263) that it is in no way connected with disease or with approaching death, but happens with individuals in full vital activity and surrounded by favourable external conditions, and adds that gemmation frequently proceeds in these encased beings, and that, when from evaporation of the surrounding fluid or other prejudicial cause the animals are threatened with injury, they quit their sheaths and swim away, the previously suctorial extremity resolving itself into a pencil of bristles. The result of these observations of Cohn is to disassociate this phenomenon of sheath-formation in *Stentor* from that of the encysting process, to which Ehrenberg's account of it would have led it to be referred.

Dr. Strethill Wright coincides with Cohn in denying the relation between the presence of the sheath of *Stentor Mülleri* and the diseased or dying state of the animalcule. Indeed he speaks of the presence of a gelatinous case as the rule, and adds that "as the zooids (animalcules) divide they form a gelatinous mass, which is attached to weeds and often to the surface of the water, from which I have seen some 10 or 15 combined *Stentors* hanging with their heads downwards."

Cilia and Ciliary Action.—The most common, and at the same time the characteristic external appendages of the Ciliated Protozoa are the cilia, which constitute their most active and powerful locomotive organs. Cilia are, moreover, not wanting internally, but are there comparatively few, since they are appendages only of free surfaces. They are met with lining the œsophagus, where they, no doubt, serve to facilitate the ingestion of food and of the water taken in for the purposes of aëration.

The nature and cause of ciliary movement have been much debated. To account for the energetic and peculiar movements of cilia, Ehrenberg imagined the existence of a muscular apparatus at their globular roots, consisting of four muscles, each pulling in an opposite direction, but, by acting in succession, causing the apparent rotation of the axis around the fixed base. This bold idea has met with no favour among physiologists, who condemn it as purely imaginary and as opposed to the simplicity of nature, to all analogy, and to all the admitted facts and principles of histology. Most inquirers despair of attaining a satisfactory explanation, of ciliary action, and treat it as an ultimate fact. However, Cohn, looking to the peculiar structure of the integument of *Paramecium* (*Loxodes*) *Bursaria* (XXIX. 26), fancied that ciliary motion admitted of explanation, since, on the supposition of an inherent contractility in that membrane, each little pyramid might be imagined to contract its sides in turn, and make the cilium surrounding it revolve in the figure of an inverted cone. But granting the possibility of this explanation in the case of the animalcule cited, it could in no wise be applied generally to ciliary motion; for a similar structure is found in comparatively few other examples, and the innate contractility of the supporting membrane, assumed in the instance in question, has certainly no existence in many ciliated surfaces, and involves nearly an equal stretch of imagination to conceive as Ehrenberg's muscles.

Returning from this digression on the nature and cause of ciliary action, let us briefly review the mode of distribution of cilia in the Protozoa. In many genera they are distributed universally over the surface (XXIX. 20, 28, 48; XXVIII. 1, 8, 31), not at random, however, but in definite parallel lines, more or less approximated, usually traversing the length of the body. A distribution in parallel lines is also not unfrequently observed across or around the body. Even where generally diffused over the body, they are commonly more developed at certain parts, as about the mouth, the head, and tail, as well as on any processes or in any depressions of the body, *e. g.* in *Chilodon* (XXIX. 48), *Bursaria*, *Leucophrys*, *Stentor*, &c. Stein represents it as a generic character, that in *Paramecium* (XXIX. 28) all the cilia are of uniform length. In *Coleps* (XXIV. 284), the lorica is divided into a multitude of minute facettes by intercurrent lines or sulci, and the cilia are placed at the points of their intersection. In *Colpoda Cucullulus* (XXIX. 35, 36, 37), the cilia are much longer at the anterior prolonged extremity, the lip, just as in *Chilodon*; but there is besides, in the deep sulcus where the mouth is found, a dense pencil of long and strong cilia (XXIX. 37), which Ehrenberg mistook for a solid process of the body, and called the "tongue." From this fasciculus or bundle, a row of long cilia is, moreover, seen to extend backwards to the posterior extremity (XXIX. 37).

Other groups of Ciliated Protozoa have the cilia confined, more or less strictly, to one part or organ of the body,—a circumstance exemplified in the *Vorticellina* and *Ophrydina* (XXX. 1, 2, 5, 9; XXIX. 1, 3, 4, 5). This limitation, as contrasted with the general diffusion of cilia, implies an advance in the scheme of organization, and is attended by the construction of a special apparatus about the head of the animalcules. Thus, in the families named, the rule is that the anterior extremity is bounded by an evident, mostly thickened margin, either curved or straight—the "peristom"—crowned with vibratile cilia and complicated by an internal, usually extensile, ciliated disk or rotary organ (XXX. 1, 2, 9 *a*, 29 *a*), the whole apparatus recalling the structure of the rotary organ of the *Rotatoria*. The cilia appertaining to the peristom and disk are highly developed and strong, although, instead of serving for locomotion, they only subserve the processes of nutrition and aëration or respiration, by reason of the fixed condition of the animalcules possessing them.

Another peculiarity of the ciliary apparatus of the *Vorticellina* and *Ophrydina* is that it is retractile (XXX. 6 *a*), or can be involuted and withdrawn into the interior of the animal (XXX. 13), and the peristom closed completely, and contracted sometimes so far as to draw in a part of the wall around it, and not leave a single cilium visible externally (XXX. 11 B, 31, 33). When thus retracted, the ciliated organ appears like an internal, irregular-sigmoid, contracted cavity or fissure, with the cilia closely packed together and scarcely distinguishable (XXVII. 5 *a*, *b*; XXX. 11 B). The retraction of the ciliary wreaths, which takes place very rapidly, is caused by the presence of surrounding objects in the immediate vicinity of the animal, by their contact with it, by any shocks it may feel, and by the presence of noxious matters in the water. On the removal of such and similar causes of annoyance, the extension of the delicate apparatus follows; this act, however, is less rapid than that of retraction, and may be arrested at any point.

A more permanent withdrawal of the rotary apparatus, in the families named, occurs when the process of self-division is about to proceed (XXVII. 3; XXVIII. 18), and also when the animalcule prepares to enter into the encysted condition (XXVII. 5, 7).

The disappearance of cilia is witnessed not only in *Vorticellina* and *Ophrydina* when the process of encysting takes place, but is a general phenomenon among ciliated organisms under the same circumstances; yet it would appear that in some cases, even when an animalcule has surrounded itself with a cyst, its cilia are not actually lost, but only withdrawn from view,—a fact adverted to by Stein in his account of *Chilodon Cucullulus*, which at times, after encysting itself and developing one or more living germs within the cyst, has been seen to renew its original appearance, to regain its cilia upon its surface, and, after rotating for a while within the sac, to burst at length through it and escape (XXIX. 55, 58). Moreover many observers have asserted the fact that an animalcule may, soon after encysting itself, be set free by rupturing the cyst by pressure, and then reassume its previous ciliated and active condition. Nevertheless the act of encysting, when advanced to a certain point, or when the reproductive process consequent upon it differs from that seen in *Chilodon*, appears to involve the final disappearance both of generally diffused cilia and of specially organized ciliary wreaths.

The arrest of the motion, and the ultimate disappearance of cilia, are phenomena attendant also on the death, or on the approaching diffluence, of animalcules—when the surrounding water dries up, or when their vitality is injured by chemical agents or by physical forces, such as electricity and heat. Stein, however, states that, although the animalcule, *e. g.* a *Paramecium*, is killed by the addition of very dilute acetic acid, yet its cilia continue visible and of their normal length. Cohn believed the cilia to be very much longer than Ehrenberg represented; but, as Stein affirms, this notion originated from an unnatural appearance consequent on the dying state of the animalcule, from evaporation of the surrounding water; and he adds that a similar elongation of cilia appears immediately at the point where strong acetic acid comes into contact with the surface. But this explanation has since been set aside by Prof. Allman's discovery of the existence of trichocysts, or thread-cells, within the subtegumentary layer of the body (XXXI. 1–4), to which he attributes the phenomena observed and discussed by Cohn and Stein.

An instance of a temporary formation of cilia is seen in the *Vorticellina* and *Ophrydina* when the offspring, formed by fission or by gemmation, is prepared to detach itself from the parent being. Under such circumstances, and prior to the development of the interior retractile ciliary organ, a wreath of cilia makes its appearance (XXVII. 4, 11) near the posterior extremity—but which, indeed, for the time, advances first in swimming, and continues to do so until the animalcule has attached itself and proceeds to unfold the ciliated apparatus at its head.

In the above account, reference has been chiefly made to vibratile cilia, but, as before noticed, there are tegumentary processes of larger size, coarser and stiffer, and withal not vibratile, although moveable. Such serve frequently as special organs of locomotion, or of prehension, or of both, and may also be occasionally considered weapons of offence and defence. According to their form they are named *setæ*, or bristles; *uncini*, or hooks; *cirri*, styles and filaments.

Some of these terms are both loosely defined and used. Thus the bristles so called of one author, are spoken of by another as cirri, or styles or filaments,—the structures thus variously called being long bristles, mostly tapering, and either straight or but slightly curved. The term "*cirri*" (in English, *tendrils*) should be disused, both as being unnecessary and also as conveying an erroneous conception; for no organs like tendrils exist among Protozoa. Uncini (hooks) are very thick at the base, strong, curved, and comparatively short processes (XXIX. 15, 17); styles are stout setiform bristles, articulated at their base to the cuticle, and of considerable length (XXVIII. 10; XXV. 350, 351). These last-named processes, Lachmann tells us, are sometimes split up at the apex into two, or even as many eight, parts, as happens in various *Euplotes* (for instance, *E. Patella*, in which species, moreover, one style bears a number of small lateral setiform branches). The divided styles occur at the posterior extremity, and are trailed along in the movements of the animals, and only occasionally employed in pushing them forwards, whilst the uncini in advance serve for actual creeping and climbing. As examples of these tegumentary appendages, may be adduced the setæ of *Urostyla* and *Kerona*; the uncini, setæ, and styles of *Oxytrichina* (XXVIII. 10), *Euplotes* (XXV. 350-353), and of *Ploesconia*. Intermediate grades, between the highly-developed setose processes cited and ordinary vibratile cilia, may be seen in the larger and more rigid ciliary structures alluded to above as often found along the margin of animalcules, on eminences and in depressions and other particular parts; such Lachmann would name "*ciliary bristles.*" In *Trichodina Pediculus* (XXIX. 17), Stein describes a circle of uncini supported on a cartilaginous or corneous ring, and external to this a yellowish membrane of corneous consistence and extraordinary flexibility, with closely-placed striæ across it. On a lateral view of the animalcule, this membrane is seen to rise round the circlet of uncini like a raised rim (XXIX. 17 *f*).

LOCOMOTIVE AND FIXED FORMS OF THE CILIATA. VARIETIES OF LOCOMOTION. TRANSITORY POWER OF LOCOMOTION AMONG THE ATTACHED GENERA. PEDICLE SINGLE AND BRANCHED. VARIED OUTLINE OF RAMIFIED STEMS. STRUCTURE OF STEM. CONTRACTILE STEMS. RIGID STEMS.—The Ciliata, with respect to the function of locomotion, present themselves under two groups,—one comprehending those genera which at all periods of their existence can move from place to place at will, the other embracing all those which under ordinary conditions are attached by means of a stem or pedicle, of greater or less length.

The former—the locomotive group—includes the larger number of genera, in all of which the cilia are more or less generally distributed over the entire body. Their swimming movements are especially due to the cilia, but may be aided by other tegumentary processes, by setæ, styles, or uncini, and in several instances by the general figure of the body. It is rare that swimming is a simple onward movement; on the contrary, it is usually attended with a rotary motion about the long—seldom the short—axis of the body; and when the animalcule is considerably elongated, it becomes undulating, as in an eel. In the case of *Spirostomum* (XXIV. 297, 298), the elongated ribbon-like figure is particularly favourable to rapid writhing motion. In short, as before intimated, the developement of the body to a greater extent in one or more parts, so as to form processes, or the constriction of a portion, reducing it to the dimensions of a member, or the lengthening of the entire animal into a band-like or ligulate figure is made subservient to the purpose of locomotion, and imparts to it a more or less special character. Moreover, the locomotive Ciliata have the power of altering the direction of their movements, and will often retrace their course, and this frequently without turning themselves round in order to advance the same extremity foremost.

The simple movement of swimming is common to all the Ciliata; but in the case of those furnished with setæ and uncini, a creeping or crawling motion is superadded, as, for example, in *Stylonychia* (XXVIII. 10), *Himantophorus*, *Euplotes*, and *Kerona* (XXV. 322, 328, 347, 353). In several of these examples we find one side of the body covered with a more resistant integument or shield, whilst the locomotive uncini or setæ are disposed along the other, just as in the case of a myriapodous insect, and supply a locomotive apparatus whereby the animalcules can run, with much activity, over the surface of an Alga or other solid body, or climb it without difficulty. The movements of the setæ, in creeping, are not independent like those of vibratile cilia, but are produced by the contraction of the substance into which their bases are fixed.

Every microscopist has observed Ciliata suddenly arrest their course and as quickly reverse it. This phenomenon Perty calls '*diastrophy*,' and asserts (*op. cit.* p. 122) that this change in movement is accompanied by such a transition, that not only does the posterior extremity become, for the time, the anterior, but it also acquires the size and appearance of the latter. There is, in his language, an actual polar reversion of the organism. This peculiarity is observed among the swimming, but not among the creeping Protozoa, which always advance with the anterior end first. When *Paramecium versutum* or *P. leucas* becomes diastrophied, its figure elongates and changes to cylindrical

—the present anterior portion (formerly the posterior) grows thicker, whilst the opposite end becomes somewhat more pointed. For a few seconds the animal swims about, revolving at the same time upon its long axis, and after suddenly making a turn, reassumes its regular form and its usual movements. It is singular that the cilia of the reversed anterior extremity acquire a greater length and strength, and act with increased vigour, whilst those at the opposite end become inconspicuous and passive. During diastrophy, moreover, rotation upon its long axis is particularly rapid. Perty illustrates this peculiar act of diastrophy in many other species, of which we may mention *Paramecium Colpoda*, *Colpoda Ren*, *Coleps hirtus*, *Oxytricha Pellionella*, &c.

A very indifferent conception can be formed of the energetic ever-varying movements of the Ciliata by any attempted descriptions of their manner and direction. One method is combined with or rapidly exchanged for another; and we see the little beings not simply swimming, but revolving and curving on themselves in a marvellous and beautiful manner, to be appreciated only by observation.

Could we imagine the existence of a will, or of a power of control, in such tiny creatures, we should say that ciliary motion is at its bidding; we see it incessantly varying in the same individual, both in activity and power, at one moment urging on the moving atom at full force, at another merely revolving it rapidly, at another slackened and presently stopped. These variations, too, appear not fortuitous, but directed to certain ends—to the procuring of food, to the avoiding of an obstacle, or to the escape from an enemy. Yet, on the one hand, the belief in the need of a special organization for the manifestation of volition, and, on the other, the observation of very similar movements in the ciliated cells of higher animals when detached and free in water, in the Phytozoa and in the spores and filiform cells of plants—are circumstances which make us hesitate in attributing such phenomena to any other than purely physical forces.

"There is no sufficient reason," says Dr. Carpenter ('The Microscope,' p. 476), "to regard such actions as indicative of a wonderful adaptation, on the part of these simple ciliated cells, to a kind of life which enables them to go in quest of their own nutriment, and to introduce it, when obtained, into the interior of their bodies."

Prof. Owen remarks, in his lectures on the Comparative Anatomy and Physiology of the Invertebrated Animals (1843), p. 19,—"If you watch the motions of the Polygastric Infusoria, you will perceive they avoid obstacles to their progress, rarely jostle one another; yet it is difficult to detect any definite cause or object of their movements." Further on, he writes—"The motions of the Polygastrica have appeared to me, long watching them for indications of volition, to be in general of the nature of respiratory acts, rather than attempts to obtain food or avoid danger. Very seldom can they be construed as voluntary, but seem rather to be automatic—governed by the influence of stimuli within or without the body, not felt, but reflected upon the contractile fibre—and therefore are motions which never tire. We may thus explain the fact which Ehrenberg relates (not without an expression of surprise), namely, that at whatever period of the night he examined the living Infusoria, he invariably found them moving as actively as in the day-time; in short, it seemed to him that these little beings never slept."

Turning now to the fixed Ciliata, we perceive that the true *Vorticellina*, not invested by an external sheath, arrange themselves under two sections, according as the stem is flexible and contractile, or non-contractile and almost or completely inflexible. The genus *Vorticella* is the type of the contractile group, and *Epistylis* that of the non-contractile and inflexible. The stem of the genus first named is always simple or unbranched (XXVII. 1, 2, 3, 4); but in that of the other genera of *Vorticellina*—viz. *Carchesium* (XXX. 9) and *Zoothamnium* (XV. 69) of the contractile-stalked group, and *Epistylis* and *Opercularia* of those having rigid stems (XXX. 1, 11)—the young beings produced by fission continue adherent to the parent stem, and then proceed to develope secondary branching pedicles of their own, and in this manner give rise to compound ramified collections of polyparies. Since this ramification is consequent on the division of a parent-being into two, it has necessarily a more or less regular dichotomous (forked) character, and will be more compound the oftener the process of fission has been repeated.

The stem produced by each half continues to acquire length and strength until the being which surmounts it begins in its turn to undego self-division, when its growth at once ceases; and it undergoes no further change whilst it exists, except in acquiring increased consistence.

" The individuals on the same stem have," says Stein (p. 75), " as a rule, similar dimensions, those undergoing fission, and therefore wider, excepted. At times, indeed, one may be found smaller than its neighbours; but this will be traceable to some accidental circumstance, such as a less supply of nutriment to it, and is never very considerable. The size of the members of the same colony agrees in general with that of the individual from which the whole have sprung. When the newly-developed fission-segment, after detaching itself from its parent, forthwith proceeds to fix itself and secrete its stalk, the newly-developed colony will coincide in dimensions with that from which this animalcule has proceeded. On the contrary, if the detached member enjoys its freedom a longer time, appropriates nourishment, and attains a larger growth, the new arborescent polypary developed from it will be larger in all respects than the parent colony. Hence it is, that in the same species we have great variety in the dimensions of individual members as well as of colonies; and therefore the height of the pedicle, the thickness of its branches, and the size of its individuals are useless as specific characteristics."

The style of ramification is equally devoid of constancy in the same species: for (to continue our extracts from Stein) " the several branches may attain an equal elevation, and so produce a corymb or cyme; or the inner may outgrow the outer branches, and the whole polypary resemble a bunch of grapes or a panicle; or, as occasionally happens, the branches may be all incompletely developed, but at the same time bear numerous individuals on short stems, arranged in close series on one side, when there will be a resemblance to an ear of corn."

In the case of *Ophrydium* there is a considerable departure from the ordinary structure and arrangement of the polyparies of *Vorticellina* and the rest of the *Ophrydina*. Ehrenberg considered the globular masses of *Ophrydium* to be constituted by the cohesion of their gelatinous sheaths, and to be the consequence of their incomplete self-division. This, however, seems to be incorrect; for Stein (p. 246) confirms the statement of Frantzius, that the gelatinous ball is not made up of coherent sheaths, but that the bodies of the *Ophrydia* are merely attached by their tapering posterior extremities to its surface, and not imbedded within it. The animal sends, indeed, a prolongation of its tapering base some short way within the homogeneous matrix, like a root; and when it forcibly contracts itself, a slight depression of the surface occurs; but in no strict sense can the gelatinous excretion be called a sheath or lorica.

Although, in their usual phase of being, the attached Ciliata have no power of locomotion, they are nevertheless capable of considerable relative movement. The highest degree of this is seen in the actively contractile stems of

Vorticella, *Carchesium*, and *Zoothamnium*, and the lowest in the nearly sessile *Vaginicola*, and in the rigid-stalked *Epistylis*. The movements of the stems of *Vorticellæ* are most astonishing by their activity and energy. In their contraction, which is much quicker than extension, the pedicle is twisted into a close spiral comparable to a coiled spring; and besides this action, by which the animal is instantaneously drawn down to the point of attachment, the body itself shortens, and the ciliated head and appendages are retracted under cover of the general integument. The branched pedicle of *Zoothamnium* is less actively contractile, although still capable of considerable movement, whilst that of *Opercularia* and *Epistylis* is quite rigid, or very slightly flexible, and this in most species only in younger stems, before they are indurated by age. In *Opercularia berberina* we have the most marked example of flexibility of the stem among rigid-stalked genera.

Apart from the movements of the animalcules dependent on their pedicles, others are due to the contraction and elongation of their bodies, and to the retraction and extension of their rotary apparatus. In the instance of *Vaginicola* (XXVII. 11), of *Cothurnia* (XXX. 12, 13, 14, 15), and of *Tintinnus*, these, indeed, are the only movements of which those genera are capable,—the external sheath constituting of itself a safe house of defence when the animalcule retreats within it, and thus offering a compensatory provision in lieu of the locomotive power of the freely-swimming Ciliata, or of the actively-coiling spiral of *Vorticella*. On the other hand, when not in retreat, the animalcule outstretches itself, and, advancing its ciliated delicate head beyond the limit of the case (XXVII. 10, 11), expands its ciliary apparatus.

The animalcules fixed on rigid stems appear exposed to every passing danger without defence; nature, however, has furnished them with a firm resistant integument within the anterior margin or peristom, of which they can completely retract the delicate rotary disc and ciliated head. However, they are not positively motionless; for a certain latitude of motion is allowed them by their mode of articulation, and by the annular segmentation of the posterior extremity (XXVII. 16), in addition to the possible contraction into an ovoid or more or less globular figure. In *Opercularia berberiformis* the contraction of the body is facilitated by the transverse rugæ which normally exist,—whilst in *Ophrydium* it is carried so far that the elongated figure becomes oval, and, the head being retracted, the animal presents itself as an inconsiderable prominence above the surface of the gelatinous mass it rests upon. The absence of a protecting sheath in this genus is partly compensated for, further, by the aggregation of the *Ophrydia*, since the globose mass produced is of itself a security, and is rendered still more so by its revolving movements, the result of accidental external forces, and, we may suppose, also by the activity of the animals projecting from its surface.

The *Vorticellina* and *Ophrydina* live as free beings for a certain time after their production, whether by fission or by gemmation, or by internal germs or embryos. In the case of the products by gemmation and fission, this locomotive power is due to the temporary formation of a wreath of cilia behind the posterior third of the body, as mentioned in a preceding page; and it is curious that it is not then the head which moves in advance, but the hinder extremity, by which attachment is to be presently made. There seems to be an object in this backward progression; for by it the animal is brought directly into contact with any object to which it can affix itself, and its attachment made more firm. The part to be attached is the first to come into contact with the supporting medium; and whether it proceeds to secrete about itself a sheath, or to develope a peduncle, it finds itself rightly placed without any revolution of the body.

STRUCTURE OF PEDICLES.—The intimate structure of the stem of the *Vorticellina* is different in the contractile and in the rigid forms. The highly-sensitive, contractile, simple pedicle of the genus *Vorticella* has challenged especial study. It is evidently a compound structure, consisting of a hollow tube containing a cylindrical band. The tube is a portion of the general integument, and continuous with it; in diameter it is uniform throughout, except at its point of junction with the body, where it undergoes a very slight expansion. Owing to the excessive rapidity of its spiral contraction, this act can with difficulty be observed, except after the addition of a weak solution of corrosive sublimate, which renders it so much slower that its progress may be watched. Ultimately, indeed, the solution kills the animal.

The contained band, or, to borrow a term from general anatomy, the "axis-cylinder," does not fill the cavity of the tube, but is disposed within it in a loose spiral manner. Opinion has been much divided as to the nature of this structure. Ehrenberg, judging from its active contractility, pronounced it a muscle, and went so far as to represent it as striated, *i.e.* as belonging to the highest-developed condition of muscular tissue, which, however, comparative anatomy teaches us is absent in the lowest classes of animals. Many other writers have united with Ehrenberg in considering the band muscular, and some few also striated, whilst others, again, have regarded it as a simple primitive contractile substance, less elevated than muscle proper in the range of tissues. Indeed, when we contemplate the contractility exhibited by certain plants, and can find nothing more than spiral vessels which can be conceived the seat of this property, we are forced to admit that muscular tissue is not the only actively contractile element in organized bodies.

Stein, after remarking that the histology of the stem in *Vorticella*, *Carchesium*, and *Zoothamnium* is essentially similar, proceeds to describe the axis-cylinder as an opaque, solid, finely-granular mass, presenting delicate longitudinal lines or stripes. In *Vorticella nebulifera*, *V. convallaria*, *V. Campanula*, and in *Carchesium polypinum* (XXX. 9), it extends into the body as a single tapering band or streak, and in other *Vorticellina* in two such diverging from one another, as remarked by Ehrenberg, who concluded them to be two muscular cords. When the stem contracts spirally, transverse lines or stripes appear in the axis-matter, which are no other than cross folds, not parallel, and most strongly marked on the concave side (XXX. 10); they have therefore no homology with the transverse striæ of muscle. That the contractile power is dependent on the contained axis-cylinder is shown by the facts, that where this is deficient at any part, as not unfrequently happens in *Zoothamnium*, that portion is rigid, as in *Epistylis* or *Opercularia*; that when destroyed by maceration, or by chemical agents, the stem is outstretched and remains immoveable; and that, as is not seldom seen both in *Carchesium* and *Zoothamnium*, this axis-matter may be torn across, at one or more parts, without the external sheath being injured: the contractility is destroyed, except in that segment which is still in continuous union with the body of the animal; and generally the pedicle is only so far and so long contractile as its axis-cylinder continues its unbroken connexion with the body.

"Although," observes Stein (p. 80), "these phenomena are in favour of the axis-matter being a muscle, yet there are others sufficiently conclusive against the notion. For instance, were the axis a muscle, its movements should cease when it loosens its hold from the object it is affixed to: but this, although asserted by Eckhard, does not happen; for when *Vorticellæ* and *Carchesia* relax their hold and swim freely about with their stems, these last are seen to actively contract in their usual spiral manner, and presently again to extend themselves. In like manner *Vorticellæ*, when detached from their stems, alternately contract and extend their bodies; and yet no one pretends to see any distinct lines or bands in their interior to be termed muscles."

Stein's conclusion therefore is, that the contained substance of the stalk of the contractile *Vorticellina* is not muscular, although it is the organ through which the will of the animal is exercised over the pedicle. Further, as the action of chemical reagents upon the enclosing tube or sheath of the pedicle corresponds with their action upon the cuticle of the body, so also is there a similar correspondence, in chemical relations, between the axis-cylinder and the internal tissue of the body.

Czermak, in his essay on the stem of *Vorticellæ* (*Zeitschr*. iv. p. 442), describes in that of *Carchesium* three distinguishable structures:—1, the hyaline colourless sheath; 2, a yellowish contained fibre or band; and 3, a finely-granular fibre lying parallel to the last (XXX. 10). These three portions he terms three isotropous helicoids, with reference to their spiral mode of contraction. Eckhard supposed the effective cause of the contractility to consist in the constant intimate connexion between the motions of the stem and those of the body: but there is no such constant connexion; for the ciliary wreath may be retracted frequently without any contraction of the pedicle. According to Czermak, the explanation of the movements is to be found in the external hyaline fibre or tube being elastic, and tending naturally to keep the stem outstretched, whilst the yellow contained filament is contractile, serving to throw the stem into folds,—the one consequently antagonistic to the other. To the third or granular element, he is disposed to attribute only a vegetative function. The elastic force of the stem is constant, whilst the contractile is momentary in operation; the result of this, coupled with its tubular structure, affords an explanation of the particular spiral mode of contraction. This, Czermak has taken much pains to elucidate by reference to physical laws, and an appeal to arguments which we deem unnecessary to reproduce here.

More recently, the idea of the muscular nature of the axis-cylinder of *Vorticellæ* has been revived by Lachmann (*op. cit.* p 229), who does not hesitate to call it a stem-muscle, and "cannot allow any value to Stein's objection, that it still contracts even when the stem is not attached to another object; for the muscle does not thus loose its insertion, as it is attached to the sheath of the stem itself by its hinder extremity, and not to the foreign object." This reply to the objection seems perfectly admissible, although for our part we do not at all perceive the necessity of regarding the axis-matter as muscle in the exact sense of the term, even if it is in function homologous with that compound tissue of higher animals. A further statement made by Lachmann is, that the muscular tissue of the stem extends upwards into the body, where it joins with the supposed muscular lamina lining the cortical layer.

The manner in which the axis-cylinder is produced and disposed, is shown by Stein to afford a distinction between the allied genera *Carchesium* and *Zoothamnium*. In the former, each branch developes its own canal and its own central substance, so that neither of them is directly continuous with the canal or the contractile matter of those portions previously formed (XXX. 9); in *Zoothamnium*, on the contrary, both the sheath and the axis-cylinder of the stalk are continuous throughout the ramified polypidom (XII. 69). It is in this genus, particularly, that the oldest portion of the stem is often solid; indeed imperfectly-developed stems occur, in which after one or more divisions this same solid and rigid condition is seen. Such varieties, as Stein points out (*op. cit.* p. 218), are to a certain extent difficult to distinguish from species of *Epistylis*; nevertheless they are never so rigid as the latter, but admit of being curved and are more elastic, and, besides all this, they exhibit transverse folds or constrictions, of different depths, which are rendered still more evident when the animals contract and shorten themselves upon their stems.

The rigid stems of *Opercularia* (XXX. 1) and *Epistylis* (XXX. 11) are solid, without internal canal and contractile matter; frequently they appear finely striated longitudinally, and in several species (*e. g. Opercularia articulata*) present transverse lines (XXX. 1), along which they more readily fracture. These last are commonly described as articulations or joints; but they occur at irregular distances, and are, even in the same species, neither constant in number, in distinctness, nor in distribution, and are consequently worthless in specific descriptions.

The substance of these rigid stems is, however, not uniform, but divisible into a cortical layer and an inner or medullary substance. This is manifest by the fact of the transverse lines, which become more evident during the limited undulating movements of the stem, penetrating only through its cuticle or covering. "On the addition of concentrated sulphuric acid," says Stein (p. 112), "the pedicle swells up, and both longitudinal striæ and transverse lines or folds vanish, the whole mass appearing homogeneous and hyaline. Tincture of iodine colours it yellow; but sulphuric acid being added, it is again rendered colourless."

COMPOUND SPECIAL ORGANS OF LOCOMOTION AND PREHENSION. THE PERISTOM AND ROTARY OR CILIATED DISK. THE SPIRALLY-COILED HEAD OF SPIROCHONA.—Before entering on the description of the internal organization of the Ciliated Protozoa, there is one set of organs, belonging to the important genera *Vorticellina* and *Ophrydina* (Ehr.), which demands our attention. The organs in question are appurtenances of the head, and consist of a ciliary wreath and a retractile ciliated disk.

Ehrenberg appears not to have recognized the existence of the ciliated disk as a special structure; for in his several generic descriptions of *Vorticellina* and *Ophrydina*, he speaks of the head as simply crowned by a wreath of cilia, more prominent at one part, which he called the forehead, and interrupted at one spot by a sort of gap where the oral aperture is placed. Stein's researches, however, show clearly that the armature of the head, in most of the genera of those families, is much more complex. The excepted genera are *Stentor*, *Trichodina*, *Urocentrum*, and *Tintinnus*, which are, in fact, not true members of the family. *Stentor* furnishes an example of the structure of ciliary wreath, presumed by Ehrenberg to belong to all *Vorticellina*, being in fact a single line of cilia fringing the periphery of the head, and bending down spirally to the mouth (XXVIII. 16; XXIX. 7, 8). *Trichodina* is very curiously fringed with an anterior and posterior wreath of cilia, and has besides a firm collar-like ring, within which is a circlet of stiff uncini (XXIX. 15, 16, 17).

In the genus *Vorticella* the apparatus is most simple; it is slightly more developed in *Ophrydium* and in *Vaginicola*, still more so in *Epistylis*, and most of all in *Opercularia* and *Lagenophrys*; lastly, in *Spirochona*, *Chætospira*, and *Lagotia*, totally exceptional forms occur. When examined closely, Lachmann says (*A. N. H.* 1857, xix. p. 118), we find the wreath is a spiral, and not a complete circle (XXIX. 1, 2, 3, 4, 7). It begins in the vicinity of the orifice of the vestibule, runs above it towards the left, and round the margin of the ciliary disk; but before it again reaches its starting-point, it descends, upon the stem of the rotary organ, into the commencement of the digestive apparatus (*i. e.* the vestibulum).... The portion of the ciliary spiral, which is outside the vestibulum, is not of equal length in all *Vorticellina*; in many—*Vorticella*, *Carchesium*, *Zoothamnium*, *Scyphidia* (XXIX. 3), *Trichodina* (XXIX. 15, 17), some species of *Epistylis*, &c.—it scarcely describes more than one circuit round the disk, whilst in *Opercularia articulata* and *Epistylis flavicans* it runs round the disk three times, and in other forms the length lies between these two extremes. This portion consists of a double row of cilia; those of the outer row are usually somewhat shorter than those of the inner, and inserted upon the ciliary disk nearly in the same line, but at a different angle, as they appear to be far more strongly bent outwards. In the vestibulum and œsophagus the cilia appear to stand in a single row. The peristom bears no cilia; those represented upon it by Stein belong to the outer series of cilia of the disk, or to that portion of the spiral which descends, on the stem of the rotatory organ, into the vestibulum. The latter also, perhaps in conjunction with the bristle above mentioned, appear to have been what induced Ehrenberg to suppose the existence of a frilled lower lip in *Epistylis nutans*, and Stein in all the *Operculariæ*.

"To see the particulars above described, it is peculiarly advantageous to observe animals which have died during expansion."

In *Vorticella* (XXVII. 1, 2, 4; XXIX. 1) we have a truncate anterior extremity, the margin of which, *i. e.* the peristom, is ciliated, expanded, and often rather rolled outwards, and has within and rising slightly above it the rotary or ciliated disk. This is separated by a fissure from the peristom (XXVII. 1, 2), except at one part, where the two are continuous, and on examination the disk, with its supporting stem narrowing downwards and outwards obliquely into the body, appears to be a fold reflected from the inner margin and surface of the peristom. The mouth opens at the bottom of the fissure or cavity (the vestibulum), and is furnished with several cilia. The ciliated disk when outstretched is elevated a little above the peristom, but can be retracted and covered in by it completely. The peristom, likewise, can so curve itself inwards as to include its own cilia within the ring of integument which closes over, like a sphincter, the whole ciliary apparatus of the head. The rotary disk has some general resemblance to a cork or plug, which can be drawn inwards by the animalcule itself, or pushed outwards, so as to serve, by its ciliated margin, to produce a vortex in the fluid, and thereby fulfil the purpose of a prehensile or purveying organ, in addition to its locomotive power when the *Vorticella* is free. The tapering basis of the disk ends below in the general cavity of the body, and is held *in sitû* by its retractor fibres, which proceed to it from the sides of the animalcule posteriorly. Its interior is continuous with the general cavity of the body.

The unfolding of the ciliary apparatus of the head is more gradual than the retraction; and, so to speak, the animal seems to feel its way by first everting a portion of its delicate peristom (according to our own observation, in a sinuous manner) along with a few of its stronger cilia, before expanding the rest.

In *Ophrydium* (XXX. 5), the disk is rather more convex on its surface, and advances somewhat higher above the peristom, but in all essential particulars resembles that of *Vorticella*. On the retraction of the disk, the peristom contracts above it into a short cylinder, and the head swells out in a globose manner (XXX. 6). Between *Ophrydium* and *Vaginicola* (XXVII. 11) there is a close resemblance in the conformation of the ciliated organs, except that, in the latter, the act of retraction agrees rather with that of *Vorticella* than with *Ophrydium*.

A truncated, thickened, somewhat everted peristom, fringed with cilia (this Lachmann denies, see above), belongs to *Epistylis* (XXX. 11) as well as to the above-named genera, and to *Carchesium* (XXX. 9) and *Zoothamnium*. It has also a similar rotary disk, only rather more developed, and its stem short and thick.

In *Opercularia*, on the contrary, the peristom is neither ciliated, expanded, nor everted in a campanulate manner, but, by the tapering of the anterior third of the body, is narrow (XXX. 1, 37), and frequently thrown into longitudinal rugæ, and withal simply truncate. Further, the disk has a flat surface, and is supported on a long stem which tapers internally to a fine extremity; and the whole organ assumes a trumpet-like figure (XXX. 1 *a*, 2 *a*, *d*). Moreover, instead of an infundibuliform fissure conducting to an oral aperture or entrance to the alimentary canal, there is a wide throat or pharynx, occupying almost the whole diameter of the peristom, having its border extended upwards in the form of a free edge (XXX. 2, 3), which Stein calls an under lip, in contradistinction to the rotary disk, which Ehrenberg represented to be a forehead and upper lip.

The tapering stem of the disk bounds one side (the upper) of the pharynx, and by its narrow extremity communicates with the general cavity of the body. The flat disk itself is surrounded by two or three concentric rows of long cilia, and when drawn inwards suffices, with little aid from the constriction of the peristom, to close that opening. When, however, contraction is more forcible and complete, this process is entirely retracted, and the peristom closed above it (XXX. 37). When in this condition—and this is true also of the other allied genera,—the only indication, as before mentioned, of the ciliary apparatus of the head is an irregularly-shaped streak or space, in which cilia may still be discerned. This irregular space is nothing more than the remnant of the pharyngeal cavity not occupied by the retracted organs.

On the retraction of the rotary disk a portion of its contents is transferred from the expanded free extremity into its stem, the quantity so removed being in direct ratio with the degree of contraction; when this is considerable the trumpet-like process appears like a mere internal lobe (XXX. 37 B, *h*).

In *Lagenophrys* the peristom is peculiar in being adherent to the narrow two-lipped aperture of the sheath; the diameter of the two orifices is consequently equal. From the peristom a long trumpet-shaped rotary organ projects, similar to that of *Opercularia* (XXX. 29, 32, 33, 34).

The most singular conformation of the head occurs in a new member of the *Vorticellina*, described and figured in Stein's admirable monograph (p. 205) under the name of *Spirochona* (XXX. 17, 27, 28). In this the ordinary structure of the head is entirely departed from; and we have in its place a convoluted spiral membrane or lamella, rolled inwards around a solid central axis, forming a sort of exaggeration of the single spiral wreath of *Stentor*. In full-grown specimens of *Spir. gemmipara*, two complete circuits (XXX. 17) are made by the lamella, each of which is morphologically the same as the ciliated peristom expanded and flattened out. The surface is clothed with cilia; and at its termination in the body, near the axis of the spiral, is placed the mouth, into which foreign substances are rapidly transmitted by the action of the cilia.

Among the several members of the families passed in review, we have seen a considerable range in the complexity of the ciliary wreath; and on extending our examination to other genera, intermediate gradations in structure may be discovered. Thus, through the simple spirally-curved wreath of *Stentor* (XXIX. 7), we have a connecting link between *Vorticella*, on the one hand, and several genera, of which, in respect of the ciliary armature of the head, *Trichodina* may be taken as the representative.

Chætospira, a new genus instituted by Lachmann (*A. N. H.* 1857, xix.), has a ciliary apparatus so abnormal and peculiar, that it would seem rather a representative of another family than one of the *Vorticellina*. The anterior portion of the body is much elongated, and supports a ciliated process, when fully extended, straight and of a sword-shaped figure, fringed along one side and at the end with cilia (XXIX. 5); but when in active vibration and twirling the animalcule onward in a spiral manner, the greater part of this ciliated process becomes curved like a sickle (XXIX. 6).

Another bizarre form of ciliary apparatus is exhibited by the genus *Lagotia*, described by Dr. Strethill Wright as a member of the family *Ophrydina*. The head of this animal protrudes a pair of horn-like divergent processes, fringed around with cilia, flat or folded longitudinally, and straight or recurved at the extremities. These ciliated appendages, together with the elongated body they surmount, enjoy a very great latitude of motion by alternate contraction and extension, and by curving and twisting in different directions. The mouth lies in the angle between the processes. The whole being may be said to stand in a position, with regard to the rest of the *Vorticellina* and *Ophrydina*, similar to that of *Stephanoceros* to the other *Rotatoria*.

INTERNAL ORGANIZATION OF THE CILIATED PROTOZOA.

SUBTEGUMENTARY LAYER; CHLOROPHYLL; THREAD-CELLS; MUSCLES.—Subjacent to the cuticle is a layer of granules and small globules, which is often spoken of as a second lamina, just as the cutis vera in higher animals is of the cuticle. Its thickness is considerable; it is hyaline, and more consistent than the contents, and, although homogeneous itself, contains a multitude of granules, and, at least in several genera (*e. g. Paramecium, Ophrydium, Nassula*), numerous chlorophyll-vesicles, often so thickly disposed as to impart a lighter or deeper green colour to the animal (XXIX. 28). In young, and also in very old, specimens this colouring-matter is wanting, and only colourless granules with a dark outline, resembling small fat-particles, present.

In Mr. Carter's phraseology this cortical lamina bears the name of the "diaphane," and is said to lie beneath the "pellicula," but not to be secreted from it. The property of contractility resides in it, whence it becomes so far analogous to the muscle or flesh of animals, that to it the term 'sarcode' may most appropriately be applied. Dujardin, however, who first employed this term, did so to designate the entire component organic mass of Protozoa; but as later observers seem to make out the presence of a somewhat dissimilar substance, of a much looser and more mucilaginous consistence, surrounded by the contractile layer in question—in other words, within the so-called abdominal cavity—we feel quite justified in limiting its signification as we have done.

That the cortical layer alone is contractile, Lachmann considers (*A. N. H.* 1857, xix. p. 126) to be shown by the fact, that "in torn Infusoria fragments of it not unfrequently contract, whilst the internal mass, the 'chyme,' which flows out, never does so." Its contractions effect the various alterations in the figure of animalcules, whilst by its greater consistence compared with the abdominal contents, and its fixity as a layer subjacent to the cuticle, it affords a surface, and even a nidus, for the attachment of the nucleus and contractile vesicle, which it therefore serves to retain *in situ*, notwithstanding the opposing forces of the circulatory current and of particles of food propelled against them (see section on Circulation). To demonstrate this quiescent cortical lamina and the inner moving stratum also, chromic acid affords the most effective means.

The cavity enclosed by the cuticle and subjacent cortical lamina is occupied by an almost fluid matter, for which the term "abdominal mucus" is suggested by Carter, and that of "chyme" by Lachmann, the former we esteem the better, although it imperfectly represents the actual state of things; for in these central almost fluid contents, two portions are distinguishable—one occurring as a stream moving around the animalcule, within and upon the cortical lamina, the other as a thinner central medium, apparently quiescent, and in direct communication with the surrounding water through the channel of the alimentary tube and mouth. To the first only of these two portions Lachmann's term 'chyme' is rightly applicable, since it no doubt represents the nutritive material drawn from the alimentary matters swallowed, and to the elaboration of which the watery fluid of the centre most likely contributes. Both portions contain food-vesicles, granules, and molecules; but the former possesses them in much greater abundance. When an animalcule dies, the central contents are the first to escape, streaming forth from the mouth as a diffluent film with granules and molecules imbedded in it; a similar discharge and "diffluence" also ensue when the protecting envelopes are torn through, and the more so when some pressure is at the same time exerted.

The following quotation from Lachmann elucidates very well several points concerning the contents of the body in general. "When," he writes (*op. cit.* p. 126), "an Infusorium is sucked out by an *Acineta*, the cortical layer or parenchyma of the body may often contract for a long time, and the contractile vesicle placed in it may also continue its contractions for hours; nay, I have observed a *Stylonychia*, which, although a considerable part of its chyme had been sucked out of it by an *Acineta*, still underwent division, so that one of the gemmules of division swam away from it briskly, and only the other half of the old animal was destroyed. This appears also, to a certain extent, to prove that the mass sucked out does not represent the true parenchyma of the body; and as it only fills the large cavity of the body in the form of a tenacious fluid mass, and becomes mixed with the nutritive matters, especially when no small masses are formed, it is certainly the most natural course to regard it as chyme. It cannot be urged against this view, that in those Infusoria which contain chlorophyll-corpuscles in the substance of their bodies, we sometimes meet with single corpuscles in the rotating mass, as they may certainly be easily loosened from the parenchyma, and thus get into the chyme-mass. The nucleus, indeed, projects into the chyme-mass; but as a general rule it appears to be affixed to the parenchyma of the body, as we do not see it rotate with the chyme-mass: in *Opercularia berberina*, Stein sometimes saw the nucleus moved a little out of its previous position by a mass of food striking against it; but as it soon returned again to its position, this rather speaks for than against its attachment."

Imbedded within the cortical layer a collection of remarkable structures is discoverable in many species—for instance, in *Paramecium*, *Ophryoglena*, and *Bursaria*—known under the name of thread-cells or trichocysts (XXXI. 1–4). We are indebted to Prof. Allman for the minute and complete examination of these bodies (*J. M. S.* 1855, iii. p. 177). He believes it was these structures which Cohn represented (as mentioned in a previous page) to be exceedingly long cilia, and which Stein, in criticising Cohn's account, affirms to be cilia of ordinary length, but appearing abnormally lengthened under external circumstances, such as the addition of strong acetic acid. Prof. Allman's description is the best we have:—

"When *Bursaria leucas* is examined under a sufficiently high power, minute fusiform bodies may be detected thickly imbedded in its walls. These bodies are perfectly colourless and transparent; they are about the $\frac{1}{2500}$th of an inch long, and may easily, even without any manipulation, be witnessed at the margin, where they are seen to be arranged perpendicularly to the outline of the animalcule, while on the surface turned towards the observer the extreme transparency and want of colour render them invisible against the opaque background, and it becomes necessary to crush the animalcule beneath the covering glass, so as to press out the green globules which it contains, in order to bring the fusiform bodies into view. To these bodies I propose to give the name of *trichocysts*.

"As long as the animalcule continues free from annoyance, the trichocysts undergo no change; but when subjected to external irritation, as occurs during the drying away of the surrounding water, or the application of acetic acid or other chemical irritant, or the too forcible action of the compressor, they become suddenly transformed into long filaments, which are projected from all parts of the surface of the animalcule; and it is these filaments which, being mistaken for cilia by Cohn and Stein, gave rise to the erroneous views just mentioned.

"The rapidity with which this remarkable change is effected, joined with the great minuteness and transparency of the object, renders it extremely difficult to follow it; and for a long time I could only satisfy myself of the fact that the fusiform bodies were suddenly replaced by the projected filaments. After continued observation, however, I at last succeeded in witnessing the principal steps in the evolution of the filament.

"It is not difficult, by rapidly crushing the animalcule, to force out some of the trichocysts in an unchanged state. If the eye be now fixed on one of the isolated trichocysts, it will most probably be seen after the lapse of a few seconds to become all at once changed with a peculiar jerk, as if by the sudden release of some previous state of tension, into a little spherical body. In this condition it will probably remain for two or three seconds longer, and then a spiral filament will become rapidly evolved from the sphere, apparently by the rupture of a membrane which had previously confined it, the filament unrolling itself so quickly that the eye can scarcely follow it, until it ultimately lies straight and rigid on the field of the microscope, looking like a very fine and long acicular crystal.

"This remarkable body, when completely evolved, consists of two portions—a rigid spiculum-like portion acutely pointed at one end, and continuous at the opposite end with the second portion, which is in the form of an excessively fine filiform appendage less than half the length of the spiculum: this second portion is generally seen to be bent at an angle on the first, and is frequently more or less curved at the free end. The form of the evolved trichocysts is best observed in such as have floated away towards the margin of the drop of water, and are there left dry by the evaporated fluid. In many of them the filiform appendage was not visible; and they then merely presented the appearance of a simple, long, fusiform spiculum.

"The resemblance of the organs now described, to the well-known thread-cells of the Polypes and of certain other lower members of the animal kingdom, is obvious. That they are entirely homologous, however, with these bodies we can scarcely yet assert. Their origin, at least, appears to be different; for, if we admit the unicellular structure of the Infusoria, we have the trichocysts apparently developed in the substance of the cell-wall, instead of being produced in special cells, as we know to be the case with the thread-cells of the Polypes."

These structures have also arrested the attention of Oscar Schmidt, Leuckart, and Lachmann. The second-named observer surmised them to be "poison organs;" and very probably they have a defensive purpose, for this is suggested both by Allman's history of them, and by Lachmann's observations (*op. cit.* p. 126, in foot-note) "of similar, but much thicker corpuscles, which presented a deceptive resemblance to the urticating organs of the *Campanulariæ*, in an animal living as a parasite" upon individuals of that family of Polypes, and "which is probably to be referred to the *Acinetina*.... In the oval embryos, ciliated on one side, which were squeezed out of the body of the mother, we were enabled to convince ourselves that these corpuscles were enclosed, from two to nine together, in a roundish proper vesicle" (cell).

MUSCLES.—Ehrenberg presumed the existence of internal muscles, to explain the varied and active movements of the Ciliata,—a presumption required by his hypothesis of the repetition of the organization of higher animals in all lower forms, but entirely unwarranted by analogy. Dujardin considered the whole bulk of the body to be composed of 'sarcode,' having an inherent contractility, and the source of all the movements. Little doubt can exist that the cortical lamina is the seat of contractility,—not that it is muscular on this account, but that, as animal tissue in its simplest condition, it possesses the property of contractility as one of the characteristics of such tissue, along with others, such as sensibility, all which, in highly-organized animals, have severally their special structure elaborated for their more complete operation and independent action. In short, in the language of physiologists, the tissues in more perfect animals are differentiated, in the lowest are not so.

This physiological fact being admitted, the existence of nerve-fibres and of nervous centres, or ganglions, can be no more than imaginary. The same follows of the supposed organ of sense, the so-called eye of *Glenodinium*, which many have concluded to be homologous with the coloured specks of Protozoa, of *Euglena*, and the like. Lieberkühn's observations would lead, however, to the conclusion that the eye-speck of *Ophryoglena* rightly deserved that epithet, and is something more than a pigment-spot. His account of it runs thus (*A. N. H.* 1856, xviii. p. 321):—"Close by the oral slit, on its concave side, lies the pigment-spot. Its form is extremely irregular, sometimes globular, sometimes ellipsoidal, in many cases toothed. Ordinarily it is so distinct as to be at once perceived; sometimes, however, it is so small that it can only be detected by close examination. In animalcules filled with strongly-refracting substances alone, it is always difficult to discover it. The pigment-spot of *Ophryoglena atra* has, on the whole, more uniformity of form and magnitude. If we squeeze down an *Ophryoglena flavicans* between the covering glass and the slider, we find that the pigment-spot is composed of a heap of minute, scarcely measurable granules, strongly refracting light. I never could discover a lens in the pigment. All the specimens examined by me possessed but a single pigment-spot. Beside this lies always a hitherto unobserved structure, the form of which is perfectly described when we call it a watch-glass on a small scale. This watch-glass-like organ is transparent and colourless, and shows no trace of fibrous or any other structure. The circular base has a diameter of about $\frac{1}{100}$th of a millimetre; its depth amounts to about a third part of this diameter; the convexity is very considerable. The watch-glass-shaped organ usually turns its convex side towards the pigment-spot; its concave side is directed towards the point of the head; it does not seem to be moveable by the animalcule. When isolated, it withstands the action of water for a longer time than is usually the case with the other parts of the body of this Infusorium. After lying some time in water, it swells up in some degree, and frequently becomes perforated by a hole in the middle. The presence of the watch-glass-shaped organ is not dependent on the presence of a pigment-spot; for *Ophryoglena atra* possesses a pigment-spot, but no watch-glass-shaped organ, while *Bursaria flava* has a watch-glass-shaped organ, but no pigment-spot. In other Infusoria with eye-spots, as in the *Euglenæ* and *Peridiniæa*, I have sought in vain for this organ. I have not met with any facts throwing light on its function."

Notwithstanding, in the interior of the Ciliated Protozoa there is not an actual homogeneity of tissue. The act of differentiation is carried so far that certain distinct organs and parts become distinguishable. Thus there is a mouth or oral orifice for the entrance of food, succeeded by a dilated cavity—an œsophagus or pharynx, which is contracted posteriorly into a tubular prolongation of various length, homologous with a digestive or alimentary tube. Apart from this rudimentary alimentary apparatus, numerous globular or vesicular spaces containing granular particles or objects evidently swallowed, are met with in the general loose contents of the body; these were the digestive sacs, or stomach-vesicles, so much insisted upon by Ehrenberg; other included organs are the contractile vesicle, a certain striated cylindrical organ in one or two genera described by Ehrenberg as a dental cylinder or teeth, the nucleus with usually its nucleolus, the red speck (eye) in *Ophryoglena*, and in one genus a pair of organs imagined by Stein to be glandular. To these contents Carter adds spermatozoida, and Perty internal germs or ovules.

We have already mentioned chlorophyll-corpuscles in some genera, and the general prevalence of fat-vesicles and granules interspersed within the substance of the body, or collected into a layer as in several of the *Vorticellina*; the collection of fat-corpuscles is remarkable in the contracted portion or base above the point of attachment, whether this be by a pedicle or not. "Perhaps," he adds, "the transverse annulations which are exhibited by the bodies of some *Vorticellina* are to be attributed to muscular fibres; at all events they do not belong to the skin, but to the parenchyma (*i. e.* the cortical lamina) of the body."

Lately, Lachmann has broached the hypothesis that an actual muscular stratum lies within the cortical layer. He writes (*A. N. H.* 1857, xix. p. 228)—"I was so fortunate, in common with my friend Claparède, as to observe an indubitable separate contractile layer, in which longitudinal striæ were generally to be detected in various *Vorticellina*, in which Ehrenberg states that he saw muscular striæ at the posterior extremity. It forms a hollow cone, the apex of which is situated in the hinder extremity of the animal, and, in the contractile-stemmed species, is produced into the muscle of the stem: in its apparent section it of course appears like two small fibres separating from each other like a fork—as which, indeed, it has hitherto been always regarded, except by Ehrenberg. This layer is very beautifully seen in *Epistylis plicatilis*, in which we may most completely convince ourselves that it is a special stratum, which possesses contractility. In *Epistylis plicatilis*, namely, during the contraction of this stratum, the non-contractile part of the parenchyma which surrounds it, with the skin covering it, separates from the contractile layer, and forms the well-known folds, whilst the contractile or muscular layer becomes shortened and thickened without folding."

Organs of Digestion, Nutrition, and Secretion.—To take the several parts or organs in succession, we will first consider those concerned in the processes of digestion and nutrition, beginning with the oral orifice or mouth. This is variously situated in different Ciliata, its position having reference to the figure and the mode of life, and being generally indicated by the particular provision made to secure a proper current of water into it, such as a tuft, a curved row, or a circlet of larger cilia, a process or a depression of the body, the axis of a convolution of the surface, and the like. Thus in *Lacrymaria*, *Enchelys*, *Prorodon*, *Coleps*, &c., it is at the anterior narrower extremity; in *Trachelius* and *Amphileptus* it has a similar position, but is besides under cover of a process of the body. In *Chilodon* a still larger segment surmounts it; in *Nassula*, *Paramecium* (XXIX. 28), and in *Pleuronema* (Duj.) it is lateral; and lastly, among the *Vorticellina* it is within an involution of the integument of the head, called the 'vestibulum,' on one side of the ciliated disk

(XXX. 1, 2). The opening of this vestibule or ante-room to the entrance of the digestive tube, *i. e.* the mouth, should not be confounded with the latter, as often has been done. A funnel-like hollow having the true oral aperture at its bottom, is met with in *Paramecium*, and may have the same appellation extended to it. Among the processes about the mouth facilitating the inglutition of food, we have just alluded to the wreaths, rows, and tufts of cilia, mostly large and strong like bristles, and to special developments of the surface of the body. Several species possess a tuft of cilia almost indistinguishable from a plaited membrane; for instance, *Colpoda Cucullus* (XXIX. 37) and *Chilodon Cucullulus* have what Ehrenberg called a tongue, but which, as we have seen, Stein has resolved into a thick pencil of ciliary bristles. A similar structure prevails in *Pleuronema* and *Alyscum* (Duj.), in *Cyclidium* and *Aphthonia* (Perty). In *Glaucoma* (XXVIII. 4) and *Cyclidium margaritaceum*, "the margins of the buccal orifice appear," says Lachmann (*op. cit.* p. 216), "to be produced into two valves which are in constant motion." A special curved or spirally-turned row of cilia directs a current into the mouth in *Stentor*, *Spirostomum*, *Bursaria*, *Chætospira* (XXIX. 5, 6), *Oxytrichina*, *Euplotes*, and *Aspidiscina*, and a nearly straight row in *Chilodon* and *Colpoda*. In *Coleps*, *Trachelius*, *Enchelys*, and *Trachelocerca*, the mouth opens immediately upon the surface without any conducting ciliary channel, and is surrounded by a simple circle of cilia. The mouth is protrusible in *Prorodon* and *Nassula* (XXVIII. 8, 65), and not distinguished by any special external array of cilia. In the true *Vorticellina* and in the *Ophrydina*, as above mentioned, the complex ciliary apparatus directs the current into a cavity, the vestibulum common to both the mouth and anus; and lastly, in *Paramecium* the cilia are uniform at all parts, and the course of food to the mouth provided for by a wide and deep tapering channel. In size the mouth varies both in different genera and in relation to the dimensions of the animals; but in all it is more or less extensile, so that foreign particles or other animalcules are engulfed within it even when their diameter equals that of the body itself.

The oral aperture opens below into a rudimentary digestive tube (XXVII. 1, 10, 11; XXIX. 4; XXX. 1, 11, 29), formed by an involution of the external integument. It is commonly a funnel-shaped space, which, for the sake of a name, may be called the pharynx or digestive tube; within this, and especially near its entrance, a few vibratile cilia are mostly seen, serving by their action to accelerate the onward transmission of the particles of food. The walls of this cavity are formed by a special very extensile membrane, which, as supporting the internal cilia, may be called a 'basement membrane.' The pharynx extends (as a gently tapering, mostly curved, tube) obliquely inwards towards the centre of the general cavity of the body, where it abruptly ends. Its length is subject to considerable variation in different genera. In *Paramecium* and allied genera, and in *Oxytrichina*, it is short and of greater relative width; in *Chilodon*, *Nassula*, *Prorodon*, and others it is continued, from the posterior extremity of the so-called cylinder of teeth, far into the interior. It is also of very considerable length in the *Vorticellina* generally, as illustrated by *Epistylis* and *Opercularia* (XXX. 1).

"In Ehrenberg's families," Lachmann tells us (*op. cit.* p. 217), "*Oxytrichina*, *Euplotes*, and *Aspidiscina* (as also in *Stentor*, *Bursaria*, and *Spirostomum*), we meet with an internally ciliated œsophagus, and a curved line open towards the right, composed of strong cilia leading to the mouth." This œsophagus always forms "an open tube, and is often collapsed at its inner extremity, and thus forms a transition to the œsophagus of the following groups.

"Many Infusoria," he continues, "have a completely collapsed œsophagus, which, as forming a tube distinct from the parenchyma of the body, and hanging freely in the alimentary cavity, is perhaps entirely wanting in some species; at least, I have hitherto been unable to detect it in *Amphileptus*, most species of *Trachelius*, *Enchelys*, *Coleps*, and *Trachelocerca*, in which it only appeared to be a canal through the parenchyma of the body: and these are generally incapable of forming roundish morsels like the species hitherto under consideration; but they usually swallow larger particles, which then pass separately into the cavity of the body, often even without being accompanied by water. It is very difficult to determine whether the œsophagus of these animals is furnished internally with cilia. In some, such as *Coleps*, this almost appears to be the case: these swim to any slimy mass, such as a deliquescent Infusorium, press the anterior extremity of the body against it, and open the mouth and œsophagus, which are usually closed, so as to form a wide canal; the mass lying before the *Coleps* then passes through this canal into the interior of its body, apparently without any swallowing movements on its part, so that it can hardly be driven in except by ciliary action. In others, on the contrary, the cilia of the œsophagus appear to be wanting, as in *Amphileptus*, *Enchelys*, *Trachelius*; these perform regular movements of deglutition, in order to overcome their prey, which usually consists of Infusoria of tolerable size: they push themselves, as it were, with swallowing motions, like the Snakes, over their prey (so that they can very rarely be fed with colour); and this never forms stomach-like morsels, except when it is contained in this form in the Infusoria devoured."

Stomach-sacs. The Polygastric Hypothesis.—The next organs, concerned with digestion, to be considered, are the stomach-sacs or vesicles of Ehrenberg—the "digestive globules" of Mr. Carter (XXVIII. 8 *f*). The former has described these to be disposed after certain definite types, which form the basis of his system of classification of the *Polygastrica*. To describe these types, we must premise that the families comprised in our group of Ciliated Protozoa represent the *Enterodela* of the Berlin naturalist, or those *Polygastrica* having a true alimentary canal uniting the stomach-sacs together, and continuous throughout from the mouth to the assumed discharging orifice. The *Enterodela* were subdivided into sections according to the relative positions of the mouth and anus. The first of these was named *Anopisthia*, in which the intestine was so curved upon itself that its two extremities were conterminous in one aperture, which therefore served the double office of a receiving- and a discharging-orifice. This curvature of the intestine further suggested the term *Cyclocœla* to express it. The families in this section were *Vorticellina* and *Ophrydina*. The next section, called *Enantiotreta*, included animalcules in which the oral and the anal apertures were at opposite ends of the body. When this was the case, the intestine might either pass straight between the openings, or be more or less twisted in its course: in the former case, the *Polygastrica* were called *Orthocœla*; in the latter, *Campylocœla*. The *Enchelia* and *Colepina* were the two families of *Enantiotreta*. The third section was the *Allotreta*, having one orifice terminal, and the other lateral, and the fourth the *Catotreta*, having the two orifices on the same side, not terminal but abdominal. The members of these two last sections, lastly, had either a straight or, more commonly, a contorted intestine, or, in other words, were either *Orthocœla* or *Campylocœla*.

Such is an outline of Ehrenberg's views of the alimentary apparatus of the Ciliated Protozoa, as advanced in his great work of 1838, and never since recalled. They rested chiefly on some imperfect observations and experiments made with coloured food, and have failed to be confirmed in the hands of other microscopists. Although diligently sought after, no one has been able to demonstrate the intestine connecting together the several gastric cavities; and what is of more weight than the absence of direct evidence, are certain facts subversive of the notion that any such tube exists,—viz. the irregularity in the course taken by the bolus of food when transmitted into the interior; the intermingling of the first- and last-swallowed morsels; the movements hither and thither, and the actual rotation within the interior of the globules called stomach-sacs; the occasional coalescence of these sacs, and the not infrequent occurrence internally of frustules of *Diatomeæ* and joints of various microscopic Algæ of great relative length to the animalcule (XXVIII. 31)—sometimes, indeed, so long as to stretch the soft body itself (XXVIII. 1). On the strength of these facts, coupled with the absence of demonstrative evidence of its truth, the polygastric theory, and the system of classification founded upon it, have together been all but universally rejected.

Meyen was one of the first seriously to examine the statements of Ehrenberg: his conclusions were quoted at large in our last edition. He rejected the polygastric hypothesis because he failed to discover the connecting intestinal tube represented by Ehrenberg, and, on the other hand, detected the rotation and coalescence of the assumed stomachs. His views of internal organization closely tally with those now generally admitted. He recognized the digestive tube, the formation of the globule of food at its apparently open termination, and its onward course into the interior of the animalcule, where it constituted one of the supposed stomach-sacs. He seems, indeed, to have imagined a sort of stomach-like dilatation at the end of the alimentary canal, which served to limit the dimensions of the food-globule there formed. The circulation of the globules he attributed to the force of deglutition and to the pressure of others subsequently swallowed: the residue left after digestion he described as escaping by an anus.

An extract from Mr. Carter's valuable paper (*A. N. H.* 1856, xviii. p. 123) may with propriety be introduced here. "I cannot," he says, "with some others, think that there is any intestinal canal in the abdominal cavity, because the digestive globules and other particles of food are constantly undergoing circulation round the *whole* of its interior. In *Vorticella*, particles of food may occasionally be seen to circulate throughout, and accumulate in every corner of its interior, particularly those which do not happen to be enclosed in globules. Moreover, the intimate resemblance which exists between the alimentary organs of higher Infusoria (viz. *Nassula*, *Otostoma*, &c.) and those of the binocular and so-called blind *Planariæ*—in the distance of the mouth from the anterior extremity, the presence of a buccal apparatus, and a simple sac-like stomach in the latter, lined with a layer of mucous substance (sarcode?), charged with the 'spherical cells' about to be described—is so great, that, with such a simple gastric organ in an animal so closely allied to these Infusoria as *Planaria*, I do not see what reason we have, in descending the scale, to expect a more complicated digestive apparatus, but, on the contrary, one still more simple, in which there would be no stomach at all,—a condition which appears to me to be common to all the Infusoria that have come under my notice."

The results of actual observation show that food is drawn into the mouth by the action of its surrounding cilia, and is thence transmitted rapidly through the pharynx and its continuation, the digestive tube, into the loose tissue of the interior, assuming at first an elongated oval shape, but which soon changes to globular in its passage. The food so introduced appears mostly like a minute drop of water holding some solid particles in suspension, and presents a clear areola around a darker centre. Its course in the interior seems to depend on the varying force of projection exerted by the contractility of the tube behind it and by the primary impetus given it by the action of the cilia; thus, the more rapidly it is propelled, the greater is the circuit it describes. Stein represents it to make a wide spiral curve of one or two gyrations in *Opercularia*, and in *O. berberina* to escape finally by a determinate discharging orifice situated at the bottom of the vestibule. In this latter species, he moreover describes the impetus of the swallowed portion to be so strong as to drive the nucleus from its usual position. Although a discharging orifice in a particular site is thus referred to by Stein in the *Opercularia berberina*, yet at another page (p. 17) he says, generally, that he has been unable to detect such a fixed vent in any animalcule, but that where the excreted matters do not, as in *Chilodon* and other species, escape by the mouth, they make their way to one particular region of the body, through which they escape, not by an opening with a visible margin, but through a rupture of the integument, which closes up and disappears immediately after their exit.

This production of a fortuitous opening for the escape of the excreta, had been previously described by Dujardin as general in the Ciliata. Siebold, on the contrary, upheld the opposite opinion of the existence of a defined anal aperture among them. In most *Stomatoda*, the anus (he writes) is generally situated at the opposite extremity of the body to the mouth, and on the under surface; but where it is absent, the mouth serves both as inlet and outlet, as among the Polypes. Cohn admits, at least in certain cases, the presence of a definite anus; for in his recent figures of *Nassula elegans* (*Zeitschr.*, 1858) he indicates such an aperture (XXVIII. 11 *g*). Lachmann is very positive on this question. He states (*op. cit.* p. 127) that "a long and careful observation of an individual will always show that the fæces are invariably thrown out at the same part of the body; and in many Infusoria we may frequently recognize the anus in the form of a small pit on the surface of the animal, even for a considerable time before and after excretion (this is often the case in *Paramecium Aurelia*, *P. Bursaria*, and *Stentor*). That the fæces are not forced through the parenchyma at any point on the surface of the body, is proved especially by the careful observation of *Spirostomum ambiguum*, and some new animals which are to be united with the *Stentors* in one family. In the former, the anus is situated at the hinder end of the animal; and close in front of it is the very large contractile vesicle. When fully expanded, this vesicle appears to be surrounded only by a thin membrane; but nevertheless we see balls of excrement, often several at the same time, on different sides of the vesicle, separating the laminæ of its apparently simple covering, and forming projections which are often nearly hemispherical both towards the vesicle and the outer surface of the body. If masses of excrement do usually penetrate through the parenchyma of the body, we should expect it to be the case here when the tension of this is so great; we should also expect to see the masses of excrement pass into the contractile space, if it were not a vesicle but only a space in the parenchyma without proper walls. Neither of these things occurs, however; the fæcal masses are not deposited from the body until they have reached the anus at the hinder extremity of the body. A similar strong expansion of a thin part of the body by fæcal masses, without any rupture, is seen, as already mentioned, in some new *Stentorina*, which are distinguished from the genus *Stentor* by their having that part of the parenchyma of the body which bears the ciliary spiral and the anus (which in all the *Stentorina* lies on the dorsal surface of the body close under the ciliary spiral, and not in a common pit with a mouth) drawn out into a thin process. In one genus, of which I observed two species (one is the *Vorticellina ampulla* of O. F. Müller) in company with E. Claparède on the Norwegian coast, and which I will describe elsewhere, this process is broad and foliaceous, and bears the rows of cilia on the margin, whilst the anus is placed far up on the dorsal surface of a thin plate. In the other genus, *Chætospira* (Lachmann), observed by me in fresh-water near Berlin, the process is narrow and bacillar; the series of cilia commences at its free extremity, and only forms a spiral when in action by the rolling up of the lamina; in this genus also the process bears the anus. In both, fæcal masses which are thicker than the process in its extension, pass through it to the anus, without breaking through it, notwithstanding the great expansion of its walls.

"Not unfrequently several balls of excrement unite into a large mass before the anus, in order to be passed out together. When an excretion takes place, the anus is seen to open (but often closes once more and opens again before the expulsion of the masses is effected), and then the fæcal masses are often expelled slowly."

He further describes the situation of the anus in Ehrenberg's *Oxytrichina* and *Euplota*, in *Colpodea* with the exception of the species of *Amphileptus* and *Uroleptus*, in the *Cyclidina*, and in *Glaucoma*, *Trachelius*, *Chilodon*, and *Nassula*, to be on the ventral surface near the posterior extremity, or at the posterior extremity itself. In *Bursaria* and *Spirostomum* it is placed at the posterior extremity, as also more commonly in *Coleps*, *Enchelys*, and *Trachelocerca*. In the *Stentorina* it occurs on the back close beneath the series of cilia, and in *Chilodon Cucullulus* it is nearly on the right margin of the body near the hinder end. Among the true *Vorticellina* and *Ophrydina* the anus opens into the vestibule very close to the oral aperture, a stout curved bristle being placed between the two (XXIX. 2 *e*, *i*).

Excepting on this point of a preformed, constant, and definite discharging orifice, there is among microscopists an almost universal accord in the preceding account of the phenomena connected with the reception and digestion of food. It would be a useless expenditure of space to insert even an epitome of the observations and arguments of only the most eminent of modern naturalists who coincide with it; it will be sufficient to cite their names and their contributions on the subject:—Meyen, in *Edinb. Phil. Journ.* vol. xxviii.; Dujardin, *Histoire des Infusoires*, 1841; Siebold, *Anatomie der Wirbellosen Thiere*, 1848; Boek, *Oken's Isis*, 1848; Wagner, *Zootomie*, sect. *Infusoria*, 1848; Van der Hoeven, *Lehrbuch der Zootomie*, 1850; Leuckart, in Van der Hoeven's new edition, 1856; Stein, *Die Infusionsthiere*, 1854; Lachmann, "*On the Organization of the Infusoria*," *A. N. H.* 1857, xix.; Carter, Huxley, and Carpenter; indeed, all British authorities, with whose works we are acquainted, who have written on the subject. This is certainly a long array of authorities against Ehrenberg's theory of polygastric organization; and almost the only advocate he has found on his side is Eckhard, once a pupil of his own. This gentleman has published some observations which seemed confirmatory, but are undoubtedly erroneous in several particulars. The following remarks, bearing specially on the subject at present under consideration, may be quoted:—

He writes—"In such forms as are not too minute, we can distinctly see how the nutriment, artificially supplied, constantly takes a *definite* course in the body: in some instances the first portion of the alimentary tube can, when not in action, be observed, as in *Epistylis grandis*; it is then frequently seen to be covered on the inner surface with cilia, which, in the *Opercularia*, may even be counted. But that this alimentary canal does not, after a short course, terminate abruptly in the body, can also be proved in the *Epistylis grandis*.

"In this animalcule a portion of colouring-matter swallowed is seen to course along an intestine and enter a cell. I also once attentively observed what appeared to be the extremity of the intestinal canal, to ascertain what the further course of the coloured particles would be. At this time the animal had not filled any of the cells in its inside; suddenly two lateral cells became filled, although I did not perceive any nutriment pass along the common tube. This clearly points out that the two cells must be in connexion with the common cavity from which they had become filled; and when, after the animal has fed for a considerable time, we see that similar filled cells are diffused throughout the body, this phenomenon affords a ground for the supposition that the intestinal cavity is of greater length than we should at first sight imagine." (Wiegmann's *Archiv*, 1846, translated in *A. N. H.* 1847, xviii. p. 433.)

M. Pouchet, of Rouen (*Comptes Rendus*, xxviii. pp. 82–516), has also adopted Ehrenberg's notion of definite gastric cells, but has been unable to convince himself of the connecting intestine. Mr. Samuelson also (*J. M. S.* 1856, p. 165; 1857, p. 104) seems to coincide with this view; but in his several papers on *Glaucoma*, cited, there occur variations in description, which very much detract from their weight in deciding on any disputed point.

Lachmann gives the following details (*A. N. H.* xix. p. 118):—"The vestibulum continues the spiral line formed by the row of cilia, constituting a bent tube, which contains a portion of this spire of cilia. In accordance with the direction of this spiral, the concavity of the tube is turned towards the right, and its convexity towards the left: on the convex side the lumen of the tube is still more enlarged, especially in the parts placed furthest inwards, where the anus opens. Between the anus and the mouth which leads further inwards into the œsophagus springs a bent bristle, which is generally long enough to project outwards beyond the peristome. This bristle is stiff, and is only displaced a little to one side occasionally, when balls of excrement, which are too thick to pass between it and the wall of the vestibulum, are thrown out from the anus; but it immediately returns again to its old position.

"From the mouth a short tube, the *œsophagus*, with a far smaller lumen than the vestibulum, leads to a rather wider fusiform portion, which we will call the *pharynx*."

This selection of terms we consider unfortunate, because it is opposed to their customary usage in comparative anatomy,—the pharynx being always said to be prolonged into the œsophagus, and not the latter into the former. In all the Ciliata, except the *Vorticellina*, the canal continuing from the oral aperture is not distinguishable into two portions or segments; and one term would suffice to designate it throughout. In that class, where a division may possibly be remarked, it would be better to call the upper segment the pharynx or œsophagus, and the lower the alimentary tube; by so doing, no false conceptions could well arise. However, in quoting from Lachmann's description we must let the words abide with the meaning he has assigned them.

To continue our extract—"In most *Vorticellina* (those with a contractile stem, and the species of *Epistylis* and *Trichodina*) the longitudinal axis of the vestibulum and œsophagus runs tolerably parallel to the plane of the ciliary disk, whilst that of the pharynx has rather the direction of the axis of the body. In these, therefore, the axis of the ciliary spiral, which is continued as far as the pharynx, changes its direction at the commencement of the vestibulum: whilst it coincided with the axis of the body outside the vestibulum, it stands almost perpendicular to it within the vestibulum and in the œsophagus. In the very elongated forms of the *Ophrydina* (Ehr.), which inhabit sheaths (*Ophrydium*, *Vaginicola*, *Cothurnia*), the longitudinal axis of the vestibulum and œsophagus coincides more with that of the body, as also in the genera

Opercularia (as circumscribed by Stein) and *Lagenophrys*, Stein; in the two latter the vestibulum is very wide, whilst in the elongated species it is narrow, but generally possesses a deep excavation for the anus."

"Besides the cilia of the spiral (ciliary wreath), some stronger cilia also stand in the vestibulum, in front of the mouth; these do not take part in the regular activity of the others, but only strike forcibly sometimes,—apparently to remove from the vestibulum coarse substances which may have got into it, and also the masses of excrement."

"The morsel passed from the pharynx into the interior of the body runs nearly to the posterior extremity of the *Vorticella*, and then, turning upwards, rises on the side of the body opposite to the pharynx. During this portion of its course, it usually still retains the spindle-shape communicated to it by the pharynx, and only here changes to the globular form, often rather suddenly: this induced me at first to think that the morsel was still enclosed in a tube during this part of its course; and this opinion seemed to be supported by the circumstance that, before and behind the morsel, two lines are not unfrequently seen, which unite at a short distance from it, like the outlines of a tube which it has dilated. Subsequent observations, however, have again shown me that this opinion is an improbable one; for the circumstances described must also occur when a fusiform morsel is passed with some force and rapidity through a quiescent or slow-moving tenacious fluid mass: the above-mentioned lines, before and behind the morsel, must be produced by the separation and reunion of the gelatinous mass, even if the morsel is not surrounded by a tube. But the existence of a tube depending from the pharynx appears also to be directly contradicted by the fact, on the one hand, that the curves described by the morsel are sometimes larger and sometimes smaller, and on the other, that the morsel acquires the globular form sometimes sooner and sometimes later, according as it is pushed out of the pharynx with greater or less force and rapidity. The masses whirled into the pharynx are not always aggregated into a morsel; but sometimes, under conditions which have not yet been satisfactorily ascertained, all the masses which reach the pharynx are seen to pass quickly through it without staying in it; they then stream through the mass surrounding them in a clear streak which, like the morsels, describes a curve at the bottom of the bell, and only mix with the mass when their rapidity of motion has diminished. A roundish morsel, which might be regarded as a full stomach, is then never formed. We might easily be inclined to regard the clear bent streak with the particles flowing in it as an intestine; and this has probably been done by Ehrenberg, who states that he distinctly saw the bent intestine in some *Vorticellina*, especially in *Epistylis plicatilis*, in which I have also been able to study the phenomenon very closely. But in this case also there are the same reasons against the supposition of an intestinal tube, as in that of the lines appearing before and behind a fusiform mass: here likewise, not only the form, but also the length, of the curve varies: whilst at one time it is but short, and soon terminates by the intermixture of the particles contained in it with the surrounding mass, it may immediately afterwards be twice as long or longer—it may even make a complete circuit and return nearly to its point of commencement beneath the pharynx—a variation which appears only to depend upon the force with which the cilia of the rotatory organ act; so that we cannot explain the whole phenomenon otherwise than that the water with the particles contained in it, streaming with some rapidity into the mass with which the body is filled, cannot mix with the latter immediately, but only when its rapidity of motion is diminished by friction,—just as we see a rapid stream which falls into a sluggish or stagnant pool, or into the sea, still retaining its independence for a certain space, so that, if it differs in its colour or turbidity from the water of the sea or pool, we may distinguish it from the latter (with which it does not mix for a long time) in the form of a streak, which is often of great length.

"When the nutritive particles in the body of the *Vorticellæ* have attained the end of the clear streak under a constant diminution of their rapidity—and in the other case, when the morsel has lost its spindle-shape and become globular—they have no longer any separate movement, but now only take part in a circulatory motion, in which all the parts in the interior of the body, with the exception of the nucleus and contractile vesicle, are engaged."

This account applies in general to the alimentary mechanism of all other Ciliata besides the *Vorticellina*, except so far as concerns the dilated lower half of the œsophagus (*i. e.* pharynx of Lachmann), which is never seen. The ciliated œsophagus ends by an obliquely truncate extremity, through which the drop of water introduced by the mouth enters the tenacious fluid mass of the interior, where it expands into a rounded vacuole or stomach-sac, which continues its onward curvilinear course until, by absorption or by expulsion through the anal outlet, it disappears. Yet it may happen, just as in the *Vorticellina*, that the water and food, instead of, as usual, being united into drops and morsels, may be mixed at once with the contents of the abdomen, and no semblance of a full vacuole be produced.

A remarkable fact is recorded by Lachmann, of the digestive organization of *Trachelius Ovum*, in which, by the way, Ehrenberg declared the alimentary canal was more easily seen than in any other animalcule. "In *Trachelius Ovum*," writes the author we quote (p. 127), "alone we see a proper stomach-wall separated from the rest of the parenchyma by spaces filled with fluid, and thus form an arborescent ramified canal, which, however, must not be confounded with the nucleus." To this statement he adds, in a foot-note,—"The animalcules devoured (*Trachelius Ovum* is one of the most voracious robbers) are always seen lying in the ramifications of the stomach, in the clear spaces between them, except in crushed animals. The clear round spaces in the parenchyma (cortical lamina) of the body, are certainly no stomachs, but contractile spaces." This structure was affirmed to the writer by Lieberkühn, and was, no doubt, seen by Ehrenberg, but misunderstood by him in most points. Its gastric character, however, has not past unchallenged, for both Cohn and Leuckhart (Wiegmann's *Archiv*, *Bericht*, 1855) assert that it is nothing more than a fibrous band extending inwards from the integument in different directions through the soft contents of the interior. In this explanation Gegenbauer seems to agree—the granular bands described by this observer under the name of "trabeculæ," appearing identical with the fibres of the two last-named writers. These trabeculæ are stated to be contractile and to have a definite arrangement, the principal one extending backwards from the long, ciliated, oral fissure along the same side of the body, and having secondary trabeculæ branching from it and proceeding to the cortical lamina, where they are lost. And although Gegenbauer speaks of an intestine-like structure prolonged backwards from the mouth, in which numerous food-globules could be seen, yet he says that there was no perceptible difference in structure to distinguish this so-called intestine from the rest of the body. Moreover he notes that the nutritive globules may be often seen passing through the smaller trabeculæ. Besides the oral fissure, he remarked another opening situated further forward than it, beneath the motile proboscis, where the tegumentary wall is thick, and connected with a trabecula extending inwards to unite with others. This opening he found to be constant in size and position, to be prolonged inwards to the chief trabecula as a wide funnel-shaped tube, often delicately plaited longitudinally, and surrounded with cilia. Artificial feeding was tried; but no colouring particles were swallowed. The existence of a digestive power is shown by the disappearance of organic matters which have been swallowed, leaving little or no residue unabsorbed. Thus other smaller animal organisms are often the prey of Ciliata; and their gradual absorption into the general mass may be occasionally watched: the same, too, is true of vegetable matters such as *Diatomeæ*, *Desmidieæ*, portions of *Oscillatoriæ*, and of various minute Algæ,—although here a certain amount of unassimilated matter in the hard lorica or valves remains over and above, to be subsequently got rid of. The changes ensuing in food during the act of digestion are illustrated by Ehrenberg in his account of *Bursaria vernalis*. This animalcule feeds very much on *Oscillatoriæ*; and on watching the fibres, they are seen, when first swallowed, to be elastic, rigid, and of a beautiful bluish-green colour, but presently they become lax and of a bright green hue, which afterwards changes to a yellowish green, and ultimately to a yellow, the filaments at the same time breaking up into detached joints.

An assimilative function is evidenced both by the foregoing facts of the absorption of foreign organized matters, and also by the circumstances, that the magnitude acquired and the activity of other functions are regulated by the quantity of nutriment received, and that after certain substances have been taken as food they may be detected in certain parts, or throughout the tissue of the animalcule. Of the latter, the introduction of chlorophyll into the subtegumentary tissue, by the medium of food containing this vegetable constituent, is an example; and in general the colour of an animalcule depends directly on the food taken, or is indirectly influenced by its quality and quantity; for an animal well nourished always exhibits its peculiar colour in the highest degree, whilst ill-nourished sickly examples present little or none.

This topic suggests another closely allied to it, viz. the artificial feeding with coloured substances, so much resorted to by Ehrenberg in his researches. It consists in the introduction of a very small quantity of some insoluble colour, not a poison, capable of minute division, into the water in which the animal floats whilst under observation. The colours generally employed are indigo and carmine, a little of one or other of which is rubbed on the wet margin of the slide, surrounding the thin glass cover, whence it gradually steals under the cover, and disperses its fine particles through the little drop in which the animalcule floats.

Another substance has been proposed as preferable, by Mr. Thomas White (*J. M. S.* 1854, p. 282), viz. the red eyes of the common fly, reduced to fine powder by pressure. By feeding animalcules with this in lieu of carmine, the disadvantage arising from the dark particles of the latter crowding the field of view and obscuring the objects is obviated; and, on the other hand, it has the actual advantage of being more readily imbibed, and therefore of appearing more speedily in the apparent stomach-sacs.

Ehrenberg imagined that the Ciliata enjoy the sense of taste, leading them to choose or refuse at will among articles of nourishment within their reach. Thus he says that, amidst a number of individuals of *Paramecium Aurelia*, some took one sort of food, and others another,—no doubt a correct observation, but insufficient to prove the existence of taste. Nevertheless it must be allowed that some animalcules are especially found in company either with certain other small animal organisms, or with particular plants, or in water holding certain matters in solution,—a fact upon which our knowledge concerning their habitats and modes of life rests, but in itself no proof of the existence of a sense of taste. Indeed, in the case of minute plants we perceive a similar apparent selection of localities abounding in appropriate nutritive matters. Another assumed vital characteristic was, that Ciliated Infusoria have a feeling of company (a fondness for society), inducing them to congregate together,—an idea requiring considerable effort of imagination to conceive, but which, we fear, will scarcely find acceptance as a fact by any person who will look abroad for parallel instances of the congregating together of the same organisms; and plenty such are at hand, even among the lowest plants.

DENTAL APPARATUS, OR TEETH.—Before quitting the subject of digestion and of the digestive organs, some notice must be taken of the peculiar formations considered by Ehrenberg to represent a *dental apparatus* concerned in the preparation of the food for digestion. This apparatus occurs in the form of a cylinder of apparent bristles (XXIV. 282, 283, 308, 309; XXIX. 48)—the supposed teeth—placed behind the mouth, as seen in *Chilodon* (XXIX. 48), *Nassula*, *Chlamidodon*, and *Prorodon* (XXVIII. 8, 65). The cylinder of teeth was further stated to be wider in front, to be able to expand itself to receive, and afterwards to contract on the engulfed particle of food, so as to crush it and drive it inwards.

To these notions of the nature and action of the organ in question, Stein cannot assent. He states (p. 128) that he has frequently tried in vain to isolate it. On killing an animalcule with solution of iodine, or with dilute acetic acid, the funnel-like tube, at times straight, at others curved, is distinctly displayed, as well in the smallest as in the larger specimens. It tapers posteriorly, and ends abruptly by an open extremity in the cavity, and is composed of the same resistant elastic membrane as the cuticle. Stein gives it the name of the "œsophageal funnel." Its wider and thicker end is truncate and dentate or serrate, having from 8 to 16 dentations: between these the membrane appears to be plaited or groved for a considerable distance downwards; and it is these plaits or folds which Ehrenberg took to be long bristle-like teeth arranged side by side. This cylinder, therefore, is nothing more than an involution of the integument. It can be retracted and appear like a tapering œsophageal tube, or be protruded like a trumpet-shaped process beyond the general surface. It has not, however, that independent motile power in itself represented by Ehrenberg; but all its movements depend upon those of the integument; for Stein has never seen it either contract or dilate, except simultaneously with the contractions of the general surface. It bends, and is doubled up under pressure, and is neither denser nor a more brittle tissue than the cuticle; nor can it be resolved into rod-like segments.

The plaited upper portion is not apparent in all species which have a homologous organ: thus in *Nassula ambigua* (Stein, p. 249) the infundibulum is smooth, although the double outline its membrane exhibits indicates its very considerable thickness.

SECRETION.—Sufficient evidence of the operation of this function is found in the Ciliated Protozoa, although no special organs or tissues can be pointed out for its exercise, unless, indeed, the pair of peculiar solid-looking organs in the head of *Opercularia berberiformis*, hereafter mentioned among accessory undetermined structures, be considered glandular (XXX. 2 *c*).

The production of cilia may be considered an act of secretion, exercised so soon as an animalcule assumes a definite outline, and, under certain circumstances in connexion with the encysting-process, repeated a second time within the life-time of an individual. Again, the excretion thrown out around Protozoa when about to encyst themselves is another example of the same process; so is also the special production of cuticular matter in the construction of the dense resisting shields and urceoli of loricated species, *e. g. Coleps*, or that of the substance used in the formation of stems and of external sheaths. Another instance of a secretion may be seen in the solvent fluid poured out for the solution of solid particles of food in the interior,—a fluid certainly not demonstrable apart, but presumable from the phenomena of digestion.

Having observed the particles of food in the abdominal cavity to be frequently surrounded by a clear space filled mostly with colourless, but sometimes with a coloured liquid, Ehrenberg at once attributed to it a digestive faculty, and termed it the bile. He speaks of this in the history of the genus *Bursaria*, where it is stated to be either colourless or reddish. In *Nassula*, again, he figures biliary glands in the shape of vesicles forming a wide circlet around the mouth, filled with a violet-coloured juice, which is discharged with the excrementitious particles, and which at first appears like drops of oil, but soon mixes with and becomes diffused through the water. The following species are enumerated as possessing one such vesicular gland: viz. *Chilodon ornatus*, *Bursaria vernalis*, *Trachelius Meleagris*, *Amphileptus margaritifer*, *A. Meleagris*, and *A. longicollis*.

The bodies thus represented by Ehrenberg as vesicular glands have not escaped the notice of Stein, who pronounces distinctly against their glandular nature, and insists upon their being nothing but sections or joints of the fibres of the *Oscillatoriæ* and other plants that the animalcules feed upon, and which, in the course of their digestion, change from green to a dusky blue, afterwards to a reddish-brown colour, and at length, when broken up, become diffused throughout the interior, and impart to the entire animalcule a reddish-yellow hue.

Cohn (*Zeitschr.* 1857, p. 143) has remarked in *Nassula elegans* numerous granules of a yellowish-brown and violet colour, either collected into heaps or scattered through the interior. On the under surface, near the anus, is usually a large violet mass, and at the opposite extremity a similar smaller one, which have been described by Ehrenberg as biliary glands (XXVIII. 11, 12). If they are not particles of vegetable-coloured food altered in hue by the process of digestion or solution, they may, says Cohn, be considered analogous to the chlorophyll-corpuscles of *Paramecium* (*Loxodes*) *Bursaria*, of *Spirostomum*, or of *Vorticella viridis*, and a special form of colouring matter. The collection of the coloured mass about the anus, and its discharge in the shape of bluish particles—facts noticed by Ehrenberg—indicate its nature to be effete and excrementitious. Yet it is not the mere crude joints of *Oscillatoria*, as Stein supposed, but matter which has been digested. The heap about the neck is by no means constant.

CONTRACTILE VESICLE.—Passing now to the other contents of the Ciliata, the contractile vesicle or space first arrests our attention. Mr. Carter would call it simply the '*vesicula*;' but this word, without the adjunct "contractile" to particularize it, seems insufficient, especially when the Latin language is used in description.

This organ is of universal occurrence among the Ciliata; it is mostly single; but in a few instances two and even three such, mostly of unequal magnitude, occur. It did not escape the notice of Ehrenberg, who has figured it in all his plates of these beings. It occurs as a clear, hollow, mostly rounded space in the interior, its precise position differing in different species. It is always placed in, or closely connected with, the cortical or contractile lamina, and is not affected by the circulatory current. In the great majority of species it is situated nearer the anterior extremity, and in very close relation with the mouth or alimentary tube: thus in *Ophryoglena*, *Bursaria*, *Opercularia*, *Epistylis*, and *Zoothamnium* it lies close upon the vestibulum within, or almost within, the region of the ciliary wreath (XXVII. 16; XXX. 9–11); in *Vorticella* and *Vaginicola* it is placed against the upper part of the alimentary tube, and in *Trichodina*, *Nassula*, and many others, near it at its termination (XXX. 5, 6, 17; XXIX. 4). Exceptions to this position are met with in *Coleps* and *Colpoda* (XXIX. 35–37), where it occupies the posterior extremity, placed very close to the external surface. When two vesicles exist, they are often placed on opposite sides of the body, the one more or less anterior to the other, as seen in *Paramecium* (XXIX. 29, 30). In *Chilodon Cucullulus* a third is sometimes seen near the posterior extremity (XXIX. 48).

On watching these clear spaces, they are observed to disappear for a few moments and again to reappear—in other words, to exhibit rhythmical contractions, a feature which distinguishes them from any other vesicular spaces. The contraction is known as the '*systole*,' the re-expansion as the '*diastole*;' these movements may be either regular or irregular, and they differ in duration in different species. Perty states that the pulsations in *Stylonychia pustulata* occupy from six to seven seconds: in *Spirochona* and *Colpoda* they are more prolonged; indeed, as Stein affirms, they are slower in the former genus than in any other animalcule he has examined. When more than one vesicle is present, no uniformity in the order of their movements has hitherto been proved, although Siebold believes they must follow some rule. As evidence of the independence of the vesicle of the general contents of the body, Lachmann records (*A. N. H.* 1857, xix. p. 126) the fact that, even after the contents of an animalcule have been sucked out by an *Acineta*, the vesicle lodged in the still present and contractile layer may continue to pulsate for several hours.

With regard to the number of these vesicles in particular species, much discrepancy has existed among observers. Siebold affirms that Ehrenberg has proceeded in a purely arbitrary manner in calling one a contractile or spermatic sac, and others, indistinguishable from it, gastric cells, and quotes in illustration the Berlin Professor's description of the vesicles of *Amphileptus meleagris* and of *A. longicollis*. To this objection Eckhard rejoined by asserting that Ehrenberg was guided in determining the nature of vesicles by certain appreciable differences in the character and contractions of different sacs, and that Siebold had erroneously represented lateral abdominal vesicles in *Stentor*, and an elongated one in *Spirostomum ambiguum*. In this, however, he was wrong, for the description of Siebold has been confirmed by Lachmann and others (XXIX. 7); and on the other hand, Ehrenberg is not so much in error respecting the numbers of these vesicular spaces as Siebold was led to suppose.

It is, indeed, only by careful and repeated observations that such variations can be reconciled. In pronouncing a space contractile, a sufficient criterion seems to be found in the circumstance of a like organ being found, in all specimens of the same animalcule, constant in position, and rhythmical in its movements. Gastric cavities or alimentary vacuoles may collapse and disappear; but this movement is not followed by renewed acts of disappearance and reappearance in regular succession, and in the same spot; for if one such vacuole do replace another, a general movement onwards in the course of the internal cyclosis may be discovered. Another test to distinguish a stomach-vesicle from a true contractile sac may be found in the use of coloured food. Now that the special contractile sac is admitted generally to be merely the central organ of a system of contractile vessels disposed at various parts of the body, the appearance at times of additional vesicles, and consequently also the discrepancies of authors as to the numbers present, are explicable by supposing the accidental dilatation of a tube here and there—as a varicose vessel,—the dilatations representing for the time additional contractile spaces.

This explanation occurred, among others, to Mr. Carter. Thus he remarks (*A. N. H.* 1856, xviii. p. 128) that in *Chilodon*, where the vesicle is normally single and near one extremity, it is not uncommon to meet, amid a group of these animalcules, various individuals presenting a variable number of contractile vesicles irregularly dispersed through the body, without one being in the true position of the 'vesicula.' "That," he writes, "the 'vesicula' does make its appearance now and then, may be inferred, as it perhaps may also be inferred that from over-irritability, or some such cause, it does not remain under dilatation long enough to receive the contents of the sinuses; and hence their accidental dilatation, and the appearance of a plurality of vesiculæ."

To this accidental dilatation of vascular channels at particular points may be referred the 50 to 60 regularly placed vesicles described by Gegenbauer in *Trachelius*, the 12 to 16 mentioned by Siebold and Perty in *Amphileptus*, and also the row of them seen along the side of *Stentor*. In this last-named genus there is a circular canal surrounding the head or ciliary wreath, which sends off a branch at right angles along the side to nearly its posterior end (XXIX. 7). In *Spirostomum*, again, a long contractile channel occupies the length of the body.

The existence of a second vesicle in an animalcule normally possessing but one, Ehrenberg explained by supposing an act of fission to have occurred prior to division of the entire being,—an explanation in which Mr. Carter concurs. But if Stein be right, the contractile vesicle does not undergo fission, but makes its appearance in the newly-formed half by an act of development *de novo*. In this statement Wiegmann concurs (Perty, p. 63).

Ehrenberg concluded the contractile spaces to be true sacs, limited by a definite membrane,—a conclusion sanctioned also by Siebold, forasmuch as, during successive contractions and dilatations, the vesicles retain the same place, figure, and number. Mr. Carter supplies direct evidence of the fact (*A. N. H.* 1856, xviii. p. 130), having observed on one occasion a vesicle remain pendent in a globular form to the buccal cavity of a *Vorticella*, "when, by the decomposition of the sarcode and the evolution of a swarm of rapidly-moving monadic particles, these two organs, with the cylindrical nucleus or gland, though still slightly adhering to each other, were so dissected out as to be nearly separate; and thus yielding in position from time to time, as they were struck by the little particles, their forms and relative positions respectively became particularly evident." Moreover, Lachmann (*A. N. H.* 1857, xix. p. 226) argues at length in favour of the true vesicular character of contractile spaces. Thus he remarks—"The mode of contraction, which differs from the other contractile phenomena of the parenchyma of the body, appears to speak decidedly in favour of the vesicular nature of the contractile space. The circumstance that, before its complete expansion, it frequently appears to be divided into two or three, is not opposed to this, as a vesicle may very well be constricted into two or more parts by the partial contraction of annular portions, or by strictures. Some other facts appear to be in favour of the vesicular nature of the contractile space, such as the phænomenon presented by *Spirostomum ambiguum*, already referred to, in which balls of excrement pass to the anus between the contractile space and the outer skin of the animal, and, although often arching the wall of the contractile space into a semiglobular form, yet never break through into it. In *Actinophrys*, the supposition that there is a membranous boundary, at least on the outside of the contractile vesicle, can hardly be rejected, as its wall, which is situated on the outermost surface of the body, must burst at the moment of greatest expansion, if it were only composed of the gelatinous parenchyma of the body."

Still the contrary opinion, viz. that the contractile spaces are mere vacuoles in the substance of the interior, without a limiting membrane, has found able supporters in Meyen, Dujardin, Stein, and Perty. The first-named writer compares them to the changing vacuoles which spontaneously generate in the vegetable protoplasm of plant-cells, by an inherent property or process known as that of vacuolation, and which is equally a phenomenon of simple animal protoplasm or contractile tissue. Indeed, there is no doubt that clear hollow spaces or vacuoles may appear and disappear within the substance of Protozoa, and that some of those remarked by Dujardin, Siebold, and others immediately beneath the integument were of this number; yet such vacuoles want the constancy in position, figure, and pulsating power belonging to true contractile sacs. Besides, as we shall presently see, the evident ramifications or canaliculi of many contractile vesicles among the Ciliata afford further grounds for distinguishing between these and mere vacuoles, which, as far as we are aware, never have such offshoots.

Another questionable point among observers is, whether any communication exists between the cavity of the contractile vesicle and the free surface near to which it is placed. The majority concur in the negative; but several, among whom are Oscar Schmidt (*Froriep's Notiz.*, 1849, vol. ix.; *Lehrbuch der Vergleichend. Anatomie*, 1853), Mr. Gray (*Silliman's Journ.* 1853), Mr. Rood (*Silliman's Journ.* 1853, p. 70), and Mr. Carter, are of opinion that a direct communication, between the fluid contents of the vesicle and the watery medium bathing the external surface, is established by means of foramina in the walls. On this question Lachmann remarks (*op. cit.* p. 227)—"In many Infusoria we see one or more pale spots upon the contractile vesicle, which may easily be mistaken for orifices, but on closer examination prove to be only thin spots in the parenchyma of the body and the skin, by which the action of the external water upon the contents of the vascular system is certainly facilitated, so that they probably serve for respiratory purposes. These round clear spots are particularly numerous upon the contractile space of *Spirostomum ambiguum*." The admission or the denial of such a communication will very much affect the opinion held concerning the nature of the office performed by the vesicle, to which we shall immediately advert.

The superficial vesicles or vacuoles before alluded to, considered by Dujardin of the same nature as the contractile vesicle itself, have not been sufficiently examined and defined of late to warrant a conclusion as to their real character: yet probably some of those spaces are no more than mere vacuolæ, whilst others are dilatations of the channels of the ramified vascular system. Mr. Carter would in general assign to them the latter character. However, we believe that many of those which have attracted attention have been isolated vesicles, developed from time time, and to be concerned in securing a more perfect aëration of the contained fluid. Siebold, indeed, went so far as to presume they opened upon the external surface, and brought their contents into relation with the surrounding water.

In figure, contractile spaces are, for the most part, round or somewhat oval, and as to size stand in no direct relation with that of the animalcules they appertain to. Examples of the prevailing figure are seen in *Ophrydium*, *Zoothamnium*, *Chilodon*, *Colpoda*, *Trichodina*, &c. Even in some of these apparently simple globular sacs, Mr. Carter discovered a series of spherical sinuses surrounding and communicating directly with them. These accessory vesicles, he tells us (*op. cit.* p. 130), are, "under exhaustion of the animalcule from various causes, so distended, and thus so approximated, as to assume the appearance of an areolar structure immediately in contact with the vesicula. Each globular sinus would, however, appear to be the proximal or largest of a concatenation of smaller ones, which diminish in size with their distance from the vesicula." This account tallies with that recorded by Mr. Samuelson (*J. M. S.* 1857, p. 104), respecting the single globular vesicle of *Glaucoma scintillans*, which "when it contracts forces the fluid into others which appear temporarily formed around it;" and these, by contracting in their turn, refill the central vesicle.

Besides the seemingly simple spherical vesicles, there are others that present evident branches and a different figure. Such, for instance, are the elongated vascular canal of *Spirostomum*, and the annular canal with its row of vesicles down the side,—which seem capable of coalescing into a continuous channel, seen in *Stentor* (XXIX. 7). In *Paramecium Aurelia* (XXV. 329), each contractile vesicle assumes a stellate form, owing to the radiating processes it sends off on all sides, and which Eckhard represented as prolonged through the body by interrupted channels. It is from the study of this *Paramecium* especially, that observers have generally arrived at the belief in the existence of vascular canals in the Ciliata, connected with the contractile vesicle as a central organ. That there exists a vascular system more or less distributed through the body, most recent microscopists are in accord: we may mention Lieberkühn, Lachmann, Mr. Carter, Professor Busk, and Mr. Samuelson.

As this apparatus will be best considered in connexion with its assigned functions, we shall speak of them together, premising our account with the history of Ehrenberg's conjectures on the nature and function of the contractile vesicle. This distinguished naturalist was led by his hypothesis of organization to seek for each of the organs of higher animals a parallel or analogue in the Infusoria; and one of the most curious analogies he hit upon was that of the contractile sac with the spermatic vesicle. In this office he represented the vesicle as receiving from the testis (nucleus) a reproductive fluid, which it again ejected among the ova (granules, alimentary vesicles, &c.) occupying the interior of the animalcule. In this peculiar notion Ehrenberg has met with few disciples: for, as Siebold has justly objected, it is a perfectly gratuitous hypothesis, without analogy in the animal kingdom; for in no animal is such a thing seen as an incessant projection of seminal fluid into the interior; and further, both the nature of the nucleus as a testis or secretory organ of spermatic fluid, and the existence of recipient ova, are at best very doubtful hypotheses.

The opinions now in vogue concerning the function of the contractile vesicle and of its prolongations or processes are that it is either (1) a water-vascular and respiratory system, homologous with that of the *Rotatoria*, or (2) homologous with a blood-vascular system, or (3) an excretory apparatus. The first conjecture presupposes a direct communication between the fluid in this vascular system and the surrounding aqueous medium; by the second, no such direct communication need be presumed; the third view is especially supported by Mr. Carter, Bergmann, and Leuckhart.

In his notions concerning the organization and function of the contractile vesicle, Stein differs from most other recent investigators. As we have already seen, he denies a limiting membrane to the vesicle; he, moreover, can neither acquiesce in the belief of the existence of outlets, nor in the respiratory purpose attributed to it by Siebold and O. Schmidt. He is even doubtful of the stellate structure, as an actual fact, in the *Paramecia*; for in *P. Bursaria*, in *Nassula*, and other animalcules this apparent structure may be, he believes, produced at will by the exercise of slight pressure, as by that of the thin glass-cover upon the object, when the diastole of the vesicle is incomplete. Again, he objects against the supposed water-vascular system and its respiratory office, that, in comparison to the large ciliated pharynx, within which a fresh supply of water is perpetually introduced, and through whose delicate walls a respiratory act may be readily conceived to take place, the small contractile space commonly appended to it appears of inconsiderable importance as an aërating organ. Further, he cannot conceive the necessity of a respiratory apparatus in any animalcule which lives surrounded on all sides by water, besides receiving it incessantly within its interior, and which can therefore so readily absorb its oxygen through its delicate tissues. Another fact adverse to this assigned function is, that the vesicles of embryos, whilst still within the parent, are seen in full activity, although in that position no renewed supply of fresh water is afforded them.

These objections of Stein lessen upon consideration: thus his opinion that the vesicle is a mere vacuole, that its radiating canals are probably accidental appearances, and his ignoring the existence of a set of vascular channels through the interior, are set aside by the direct observations of several naturalists to the contrary. So, although his arguments, generally, against the presence of a special respiratory apparatus are not without force, yet the remark that he can conceive no need of such an apparatus in animalcules so circumstanced as the Ciliata is worthless as an argument; for in all such inquiries into the phenomena of life we are not to suppose an organization and then to find it, but, on the contrary, to discover facts, and then, if possible, to determine on their nature.

That the contractile vesicle and its connected channels do not constitute a water-vascular and respiratory system, is also the opinion of Lachmann and Carter. The former able observer has confirmed and extended our previous knowledge of the vascular apparatus, and thus conveys his researches and opinions (*op. cit.* p. 224):—"When the contractile space (of *Paramecium Aurelia*) is full and wide open, the rays can only be observed as fine lines, or, when the light is not good, are entirely imperceptible; by the sudden contraction of the space, however, they instantly swell into a pyriform commencement close to the position of the contractile vesicle which has disappeared. With favourable illumination, when the animals possess the proper degree of transparency, the rays may be traced in *Paramecium Aurelia* across the half of the animal, and we may sometimes perceive a bifurcation of one or other of them. During the slow reappearance of the contractile space, the rays gradually decrease; and they have almost entirely disappeared, or become reduced to fine lines, when the vesicle has attained its full extension. These rays, as well as the contractile spaces, lie, as in all Infusoria, close under the skin ('cuticula' of Cohn), in the parenchyma of the body ('cortical layer' or 'cell-membrane' of Cohn).

"In many *Vorticellæ* we also find processes going off from the contractile vesicle (Ehrenberg even states that he has frequently seen the contractile vesicle of *Carchesium polypinum* lobate or almost radiate); of these I have been able to trace one particularly, in *V. nebulifera*, *V. Campanula*, and *Carchesium polypinum*, up to close beneath the skin of the ciliary disk; this, when seen from above, exhibited a longish section. From this a fine branch appears to run, on the upper wall of the vestibulum, transversely across this to the other side; at least, I have seen a thin process hanging down like a short curtain into the vestibulum from the side turned towards the ciliary disk, which swelled up when the above-mentioned process became enlarged in consequence of the contraction of the vesicle.

"In *Dendrosoma radians* (Ehr.), a fine vessel runs through the whole length of the body, and sends branches into its ramifications: it is furnished with a number of contractile spaces, partly in the stem and partly in the branches.

"The processes of the contractile space are seen with remarkable distinctness in the large *Stentor polymorphus* (including *S. Rœselii* and *S. Mülleri*), in which a very considerable portion of a vascular system may be recognized. The large contractile space lies a little to the left of the œsophagus, near the plane of the ciliary disk. From it a longitudinal vessel runs to the posterior extremity of the animal, and an annular vessel round the ciliary disk (*Stirn*) close under its series of cilia. Both these are visible even during the expansion of the contractile vesicle, but swell up suddenly like the vessels of the above-mentioned Infusoria during its contraction: at this time the longitudinal vessel usually exhibits considerable dilatations, which, when superficially examined, may easily be taken for independent, disunited cavities (vacuoles). The annular vessel exhibits a more uniform lumen; only two roundish dilatations make their appearance in it—one close to the anus on the dorsal side of the animal, and the other close to the œsophagus on the ventral surface. Both vessels gradually decrease during the reappearance of the contractile vesicle, apparently without any contraction of their own, in the same way as the vessels of the *Paramecia*. The longitudinal vessel of the *Stentors*, and a similar one in *Spirostomum ambiguum*, were first described by Von Siebold, whilst their existence has been erroneously denied by Eckhard.

"As we thus find a vascular system in the *Stentors*, and in other Infusoria recognize the parts lying nearest to the centre (the contractile space) sometimes easily and sometimes with difficulty, we may certainly conclude that such a system exists in all Infusoria which possess a contractile space, even when no branches have been detected running out from this. That this system does not merely consist of accidental chasms in the parenchyma of the body (vacuoles of Dujardin), is apparent from its regularity. When it is asserted, in proof of the inconstancy of these vacuoles, that exactly similar ones frequently make their appearance in other parts of the body, this appears to me to arise from very different things being confounded together. The swelling dilatations of existing vessels are certainly often regarded as such vacuoles, without its being remembered that these dilatations always gradually decrease again, whilst the true vascular centres, the contractile spaces, always diminish suddenly in healthy animals. Moreover, in diseased Infusoria, an exudation of a fluid, with which the parenchyma is normally imbued, appears to take place from it even into the cavity of the body, and perhaps into chasms of the parenchyma, as we often see it take place in Infusoria and many other low invertebrate animals, on the surface of the body. These sarcode-drops appear to be incapable of ever being again absorbed; but their formation always appears to lead, although slowly, to the death of the animal."

After the above details, Lachmann inquires the nature of the function this vascular apparatus performs; and having satisfied himself of the nonexistence of a communication between the interior of the vesicle and the external surface, he rejects the idea of its being a water-vascular system, as "we do not possess the certain proof of one of the most essential requirements of a water-vascular system—the existence of an external orifice,—and some things appear directly opposed to it."

Mr. Carter coincides with Lachmann in many particulars respecting the structure of the vascular system of Ciliata; but in others he materially differs:

for instance, he thinks he has made out the existence of apertures opening on the free surface whether of the alimentary tube or of the general integument, close to one or other of which he always finds the vesicle; and, with this view of the structure, he connects the function of an excretory organ with the sac in question.

To support this view respecting the office of the contractile vesicle, he advances the following observations (*op. cit.* p. 126):—"1st. It is always seen either close to the pellicula or close to the buccal cavity, and always stationary. Thus, in *Paramecium Aurelia* it is close to the surface, and although it, of course, passes out of view as the animalcule turns on its long axis, yet it always reappears, after contraction, in the same place,—while in *Vorticella* it is attached to the buccal cavity, and, being centrically situated, seldom passes out of view, except when it disappears under contraction, after which it also reappears in the same place.

"2nd. In *Actinophrys Sol* and other *Amœbæ*, during the act of dilatation, the vesicula projects far above the level of the pellicula, even so much so as occasionally to form an elongated, transparent, mammilliform eminence, which, at the moment of contraction, subsides precisely like a blister of some soft tenacious substance that has just been pricked with a pin.

"3rd. Lastly, when we watch the contraction of the vesicula in a recently encysted *Vorticella*, we observe that at the same moment that it contracts the buccal cavity becomes filled with fluid, and, further, that this fluid disappears from the buccal cavity, and all trace of the latter with it, long before the vesicula reappears,—thus proving at once that the fluid comes from the vesicula, and does not return to it, whatever may become of it afterwards.

"The position of this organ, then, its manner of contracting, and the buccal cavity of encysted *Vorticella* becoming filled with fluid the moment it disappears (where we know it to be attached to the buccal cavity, and not to the pellicula), are almost conclusive of its excretory office."

Adopting Spallanzani's observation (which, however, wants confirmation to establish it as the rule) that the fusiform sinuses of *Paramecium Aurelia* become empty as the vesicle fills, and do not reappear until some time after it has contracted, he infers "that the fluid with which the vesicula is distended comes through the sinuses, but is not returned by them to the body of the *Paramecium*."

"Now in some cases," he continues, "faint hyaline or transparent lines may be seen to extend outwards from each of these sinuses, which lines, Eckhard has stated, 'traverse the body in a stellate manner.' Hence, when we add Eckhard's evidence (which I have been able to confirm in a way that will be presently described) to the observation of Spallanzani, and connect this with the facts already adduced in favour of the excretory office of the vesicula, it does not seem unreasonable to conclude that the whole together forms an excretory vascular system, in which the vesicula is the chief receptacle and organ of expulsion.

"While watching *Paramecium Aurelia*, I on several occasions not only observed that the vesiculæ were respectively surrounded by from seven to twelve pyriform sinuses of different sizes, and that lines extended outwards from them in the manner described by Eckhard, but I further observed that these lines were composed of a series of pyriform or fusiform sinuses, which diminished in size outwards; and frequently I could trace as many as three in succession, including the one next the vesicula. Hence I am inclined to infer that this vascular system throughout is more or less composed of chains of such sinuses, and that all have more or less contractile power like that of the vesicula. Just preceding death, when *Paramecium Aurelia* is compressed, and under other favourable circumstances, these sinuses run into continuous hyaline lines, and may not only be seen extending in a radiated vascular form across the animalcule, but even branching out round the position of the vesicula, which, having now become permanently contracted, has thus poured back the contents which render them visible. They enter the lower or inner part of the organ, and at this point, therefore, are pushed inward as the vesicula becomes distended. Under the same circumstances, also, when the vesicula is slowly dilating and contracting, it may be seen to be attached to a small papilla on the surface, about twice the diameter of those which surmount the trichocysts, and through which it probably empties itself (XXVIII. 25). In *Otostoma* there appears to be a similar arrangement of vesicles round each vesicula; and here also they seemed to me to be branched—at least such was my impression after having watched this animalcule for a long time in order to determine the point."

"Of the use of the vesicula and its vascular system," Mr. Carter concludes, "we are at present ignorant, further than that its functions are excretory; and when we observe the quantity of water that is taken into the sarcode with the food, and try to account for its disappearance, it does not seem improbable that the vesicula and its vessels should be chiefly concerned in this office. Another service, however, which it performs, is to burst the spherical membranes of *Vorticellæ* and *Plœsconiæ* when they want to return to active life after having become encysted: this it effects by repeated distension, until the lacerated cyst gives way sufficiently for the animalcule to slip out."

"Should it have any other uses, they are probably similar to those of the 'water-vascular system' of *Rotifera*."

In answer to the question, if all vacuolar spaces, excepting those produced by the deglutition of food, belong to this excretory system of contractile sinuses, he replies—"Certainly, where there is a plurality of actively-contracting vesicles without the appearance of the vesicula, as in *Chilodon Cucullulus*, we may, as before stated, attribute this to a kind of over-irritability or constrictive spasm of the vesicula, and therefore consider that these vesicles are accidental dilatations of the sinuses in connexion with it, as we may set down the dropsical state of *Himantophorus Charon* (Ehr.), and other animalcules of the kind, to an opposite condition of this organ, viz. that in which it is unable to relieve itself of its contents: this I have often seen occur under my own eyes."

Many thanks are due to Mr. Carter for his painstaking investigation on this subject. We are nevertheless very doubtful of several of his details of structure. For example, he describes globular sinuses to appear around the vesicle when an animalcule is exhausted, and those of *Paramecium* to run into radiating hyaline (moniliform) lines just before death and under a certain amount of compression. Now, such conditions are ill-adapted to accurate research; and knowing how readily the integrity of the soft filmy substance of the Protozoa is disturbed, and diffluence induced, by unfavourable external circumstances, the observation in question must be received "*cum grano salis.*" Moreover, looking to most of his figures (which, we regret, are rather diagrams than exact delineations after nature), the impression forces itself upon the mind, that he has many times mistaken the commencement of diffluence, and, in some instances, vacuolation resulting from the entrance of water into the tissues, for the manifestation of sinuses about the contractile vesicle or scattered over the body in connexion with it. Thus we should rather attribute the several vesicles this naturalist saw in different numbers, and variously and irregularly dispersed, in different specimens of *Chilodon Cucullulus*, to one or other or to both of the conditions we have mentioned, than to the purely hypothetical notion of the presence of a state of "over-irritability" in a presumed vascular network. It is here worth calling to mind Stein's belief that gentle pressure may give rise to a stellate or branched appearance of the vesicle, and that the conflicting accounts between Ehrenberg and Focke are reconcileable on the supposition of this occurrence (Stein, p. 240).

With reference to the hypothesis that the vascular apparatus is only excretory in function, we may remark that the exercise of such an office is no bar to that of a respiratory function, since the latter is in itself in part an excretory process, and among the lower Invertebrata many examples might be cited where one and the same mechanism is equally respiratory and excretory in purpose.

We may add that Mr. Samuelson (*J. M. S.* 1857, p. 105) agrees with Lachmann in attributing to the contractile vesicle a cardiac nature, and supplies the following particulars:—"In *Paramecium caudatum* a species of *Amphileptus*, a freed *Vorticella*, &c., I have frequently and clearly traced the canals that empty themselves into the contractile vesicle. In the second-named species these canals were very perceptible; they proceeded along the edge of the body where the cilia were the most active (also probably because there the current of fresh water would be constantly renewed), and, at the embouchure into the central vesicle, swelled into a bulb-shape. In the *Vorticella, the contractile vesicle had a canal which either communicated with the external surface through the oral aperture*, or passed *round* the oral wreath. I was inclined to believe the latter to be the case (perhaps my bias may have influenced the observation).

"In certain Infusoria there appears to be a more active vital power than in others. Thus in *Glaucoma*......(especially such as are probably larval forms), the contractile vesicle appears to have the power only to form a row of auxiliary vesicles around it, whilst in *Amphileptus* (which approaches the Planarians in its character), the Setifera or bristle-bearers, and other types it is more powerful, and the fluid is ejected with sufficient force to work its way into the body, and form canals or arteries, however primitive they may be. The progressive vitality I have often noticed in the same form at different stages of its growth."

On a survey of the facts and opinions now passed in review, it seems to us that the contractile vesicle is a closed sac representing a central circulatory organ or heart in its most rudimentary condition; that this cardiac sac propels its contents through a more or less complex system of channels, probably walled, extended through the cortical lamina of the body; that the contents represent a chyle or blood, formed by the process of digestion, and absorbed by the vessels; that this chyle is exposed in the cardiac pulsating vesicle especially, and in the ramified channels less, to the indirect action of the water incessantly introduced within the body, or constantly surrounding it externally, and thereby becomes aërated, and consequently in all probability further elaborated; lastly, that the perfected chyle is circulated through its channels, and brought by them into the immediate vicinity of the tissue in which the most active vital changes are going on, and which, on account of its higher differentiation, especially when in the form of cilia, integument, &c., demands the greatest supply of nutritive matters to repair its waste and to provide for the processes of growth and development perpetually proceeding in it or in its appended organs.

Since the foregoing review of the structure and functions of the contractile vesicle was written, Lieberkühn's valuable contribution, founded on original researches chiefly concerning *Bursaria* and *Ophryoglena*, have come into our hands (*A. N. H.* 1856, xviii. p. 323). Since the introduction of it piecemeal in our history of the organ would both have sacrificed its merits as an original essay and have disturbed the continuity of our own account, we have determined to reproduce it here as a supplement.

After describing the existence of two vesicles in *Ophryoglena* and *Bursaria*, one near the mouth, the other situated posteriorly, he goes on to say that if we examine a *Bursaria flava* containing only the smallest forms of the strongly refractive granules, "with a power of 300 diameters, we perceive near the surface a quantity of light streaks, which run together towards the contractile vesicle from the anterior and posterior parts of the body, in more or less considerable curves. In each streak we detect an extremely delicate but perfectly distinct canal, terminating ultimately in the contractile vesicle; its walls and its contents are readily distinguished by their different refractive power. When one of these canals is traced backwards from its orifice, we may often perceive, after it has run a short distance, a ramification: this may frequently be traced to one of the extremities of the body, and sometimes it gives off another branch; ultimately the canals become so excessively fine that they are invisible. Their opening into the vesicle and their course in running from it are seen very distinctly when the contractile vesicle is turned directly upwards; we may then recognize how the canals run between the contractile reservoirs, which lie very close to the surface of the body, and between the surfaces of the body inside the cortical substance; and the orifices may likewise be seen. Another remarkable position is when the nucleus is turned next the observer at the surface of the body; the canals are then seen remarkably clearly on its bright background. A few canals always run over directly, with a slight curvature, towards the posterior part of the mouth. When the animalcule lies so that the contractile vesicle appears at the margin of the body, there is sometimes an appearance as if one or more of the canals opened externally at this point; but close examination shows that they curve round and run towards other parts of the body.

"The number of vessels opening into the contractile vesicle in *Bursaria flava* is about thirty; this number, or a few more or less, existed in all the specimens which I examined in reference to this point. They are apparently uniformly distributed over the whole surface.

"The specimens of *Bursaria flava* with two contractile vesicles have the system of canals double, each system grouped independently around its reservoir. The canals of the posterior reservoir stretch into the district of the anterior; but I have never been able to detect any communication between the two. In the *Ophryoglenæ* from the Spree very little could be detected of the canals, even when the interior of the body contained only slightly refractive substances. When a suitable specimen is somewhat compressed between the glasses, so that it cannot move about, the vessels are especially seen when they have the nucleus for a background, and when they end in the contractile vesicle.

"I have never been able to trace any vessels into the interior of the body—for instance, towards the nucleus. I am also ignorant at present whether that part of the contractile vesicle which is turned toward the centre of the body of the animalcule receives any vessels.

"Both *Bursaria flava* and *Ophryoglena flavicans* belong to those Infusoria in which the contractile reservoirs may assume the well-known stellate form. Von Siebold describes this phenomenon in *Paramecium* in the following words:—'These pulsating spaces have a very striking shape; they consist of two central round cavities, around which stand from five to seven smaller pear-shaped reservoirs, with points directed outwards in the shape of a star. In the pulsation of these strange star-shaped reservoirs sometimes the stars disappear entirely, sometimes only the central round spaces, and sometimes only the rays.' The opaque *Bursariæ* exhibit this phenomenon just in the same way as it is described by Von Siebold; and those specimens in which the vascular system can be detected, offer the explanation of it. The small pear-shaped spaces are really the commencements of the vessels, which expand with the accumulated fluid; and the rays are the further prolongations of the same, which may be traced to the ends of the body.

"At the moment when the contractile vesicle has attained the greatest expansion (that is, when the diastole is terminated), it appears in the form of a globe filled with colourless fluid, from which the vessels run out on all sides in the cortical substance as canals, apparently of equal diameter; they have at this time the smallest diameter they can assume at their embouchure into the reservoir. In opaque specimens, this is the moment when the opened contractile vesicle is observed. A little before we observe the commencement of the systole, the vessels begin to expand slowly, at points distant about one diameter of the contractile vesicle from the surface of the latter, to many times their original size. The more the systole progresses, the wider and longer become the swollen places, and they approach gradually to the contractile vesicle. If we make an observation at the moment when the diameter of the contractile vesicle is diminished to about one-fourth of its original size, the shape of the apparatus agrees in all essential points with the well-known stellate figure represented by Dujardin in *Paramecium Aurelia*, with the single exception that the embouchures of the rays are distinctly visible, and their peripheral prolongations run out widely in the form of canals over the entire animalcule. Opaque specimens of the *Bursaria* display the phenomenon only in such a degree that the rays terminate in delicate attenuated points, at a distance of about one diameter of the reservoir from the latter. When the contractile vesicle has closed completely, the fusiformly-expanded vessels only are seen, as they run together with their apices to one point. This completes the systole. The diastole then recommences. If we examine the animal at the moment when the reservoir has again attained half its greatest diameter, we find a totally different appearance from that at the corresponding epoch of the systole. The vessels are not expanded now in the form of a spindle, but of a funnel, with the base of the funnel in the contractile vesicle, and the point prolonged out into the vessel. This is the form which Ehrenberg has figured in *Paramecium Aurelia*, only omitting the further prolongations of the vessels. Von Siebold rejects Ehrenberg's figure and recognizes Dujardin's; but both are really correct, only representing different instants; Dujardin gives a stage of the systole, Ehrenberg of the diastole.

"The more the contractile vesicle now expands, the more is the depth of the funnel decreased, and its diameter proportionately increased; or, in other words, the vessel expands only at its embouchure, and the depth of the expanded part decreases in proportion with the advance of the diastole. In opaque *Bursariæ* we see at this time only the contractile vesicle produced out in various directions into short funnel-shaped processes. By degrees these processes entirely disappear,—the contractile vesicle having expanded to its original volume. We now see again how, from the fully-expanded contractile vesicle, the whole of the vessels run out in the cortical layer, in all directions, as slender streaks; in opaque specimens only the contractile reservoir is visible.

"The processes above described are those usually observed when a suitable specimen is placed so that it cannot move, or only move very little, upon the slider. If, however, a *Bursaria* is compressed somewhat more with the covering-glass, or if the water on the slider is almost all evaporated, some other peculiar phenomena present themselves, not only in the contractile vesicle, but in the vessels. The last diastole coming perfectly to rest, and nothing unusual being observed, except that the reservoir is more elongated, with the systole appear suddenly two contractile vesicles instead of one; that is, a portion of the surrounding substance makes its way across the middle of the contractile vesicle while it is contracting, and thus divides it into two parts. Each of these two new reservoirs has its own systole and diastole. In most cases their contractions do not occur at the same moment. Each is in connexion with those vessels which opened into it before the separation. The vessels exhibit the same play as if there were but one uninjured contractile vesicle. Sometimes the two reservoirs reunite into a single one. I saw this happen during a diastole which occurred exactly simultaneously in both: they advanced near together, projected out points toward each each other, which came in contact and formed a dumb-bell-shaped reservoir; and this was rapidly converted into a globular vesicle, which contracted and expanded as at the origin.

"Von Siebold has already observed in *Phialina vermicularis, Bursaria cordiformis*, &c., 'that in strong contractions of the whole body, a largish round pulsating space was drawn out longitudinally, constricted in the middle, and at length was separated into two smaller round spaces—exactly as occurs when a drop of oil is separated into two portions.' During the above-described alterations in the contractile vesicles, alterations ordinarily take place in the vessels also. Thus expansions appear in them at points lying very distant from the contractile reservoirs. These enlargements are not, however, subject to rhythmical disappearance and reappearance, but are permanent; they are filled with the same colourless fluid as the contractile vesicles, and are mostly globular or ellipsoidal. If such enlargements of the vessels are seen in specimens which, from unfavourable optical conditions, do not display the vessels themselves, they may be taken for vacuoles (in Dujardin's sense). Their connexion with the vessels, and their mode of origin, which is readily accessible to observation, prove that they are totally distinct from the vacuoles in the interior of the body, part of which contain nutrient substance, while part do not.

"I have not succeeded in any case in isolating a membrane of the contractile reservoir or of the vessels. I find no trace of cilia in the interior of the vascular system. This alone suffices to distinguish essentially those Infusoria furnished with vessels from the *Distoma*-embryo in which G. R. Wagener has discovered ciliated vessels.

"Different hypotheses have been put forth in explanation of the function of the contractile vesicles. There is a detailed account of these in Claparède's paper on *Actinophrys*. Claparède rightly explains the contractile vesicles as organs of the circulation. As to the direction in which the fluid flows in the vessels, nothing can be directly observed in most cases, since we cannot perceive in the fluid any solid corpuscles at all similar to the blood-corpuscles of other animals. Is it a perfect circulation? or does the fluid flow back again in the same vessel in which it has been propelled forward by the contractile vesicle? or are the contents of the contractile vesicles constantly expelled externally? The last view has been set up by Oscar Schmidt. He states that he has seen the place of exit in the genera *Bursaria* and *Paramecium*. Claparède is opposed to this, since, in the most minute examination, he was unable to discover that the contents of the contractile vesicle were expelled externally in the systole. *Actinophrys* is better suited to the settlement of this question than a ciliated Infusorium. I have many times sought for currents in the fluid surrounding *Actinophrys Sol* and *A. Eichhornii*, when the fluid contained masses of fine globules immediately in front of the projection of the contractile reservoir; but I have never seen, any more than Claparède, any corresponding displacement when the vesicle contracted. In *Bursaria leucas, B. Vorticella, Paramecium Aurelia*, and *P. Chrysalis*, I obtained the following results:—The contraction takes place exactly in the manner described by Schmidt; the vesicle contracts from the interior of the animalcule towards a point lying near the surface, and it expands on the entrance of the fluid in such a manner that it increases in diameter gradually from the surface of the animacule inwards toward the centre. But does this teach us what Schmidt concludes from it, that the reservoir expels its contents outwardly every time when it contracts toward the outside, and becomes filled from without when it expands toward the interior? If the contractile reservoir is attached by that part turned toward the surface of the animalcule to the internal surface of the cortical substance, while the portion projecting into the interior of the body is free in the soft medullary mass, will not the contraction take place from within outwardly, and the expansion from without inward, whether the fluid flow inwards or outwards? In *Actinophrys*, sometimes in *Arcella vulgaris*, and in *Urostyla grandis*, a totally different import must be attributed to the contractile reservoir, if Schmidt's criterion be valid; for here the reservoir does not contract toward the surface, but toward the interior of the body, and forms an elevation on the surface when it becomes filled, as described minutely in *Actinophrys* by both Von Siebold and Claparède. But it is not on this alone that Schmidt rests his opinion: he asserts that he has observed also an actual external orifice of the contractile vesicle. I must admit that *Bursaria Vorticella* has a distinct orifice at the hinder part of the body, and this exactly at the place to which the contractile vesicle contracts until it vanishes. But regarding this orifice which I saw, only so much is established—that it is the anal orifice which Ehrenberg has already described. I have seen the emergence of remains of devoured substances, of loricæ of *Bacillaria*, of fine undeterminable granules, &c., from this very hole, so frequently, that there can be no doubt on this point; and it is even not rare for a corpuscle to slip out from the anal orifice during the diastole,—that is to say, at the very time when, according to Schmidt, the fluid should flow in from the outside. I found the *Bursaria* just named during spring and summer in standing water near Tempelhof; it agrees in the main with Ehrenberg's *Bursaria Vorticella*. The buccal orifice is situated as in *Bursaria truncatella*, in which, however, I did not observe any contractile vesicle at the posterior end of the body. The specimens of *B. truncatella* I observed were all about $\frac{1}{3}$ of a line or more long, those of *B. Vorticella* at most $\frac{1}{6}$ of a line. The latter is in any case not a *Leucophrys*; therefore, in case Ehrenberg considers his *Bursaria Vorticella* a *Leucophrys*, it is a different animalcule from the latter. I was equally unable to satisfy myself of the correctness of Schmidt's view in the *Paramecia*. When a specimen of *Paramecium Aurelia* lies so that the contractile vesicle, either the anterior or posterior, is seen at the margin, it appears, under certain circumstances, as though a short canal ran directly out through the integument of the animalcule; but in reality it only runs into the integument, and turns round toward the side of the body directed away from the eye: I found the same in *Paramecium Chrysalis* also: it was always one of the rays of the contractile vesicle which presented to Schmidt the appearance of an external orifice. The same is the case in *Bursaria flava*, where I could always trace the curvature of the vessel toward the opposite side of the body most distinctly. F. Stein strongly questions the external opening of the contractile vesicle in the *Vorticellæ*. Hence it is clear that the explanation of the contractile vesicles as part of a water-vascular system is unproven.

"Is it, however, established, on the other hand, that the contractile reservoirs pour back their contents again into the parenchyma whence they receive it, as Von Siebold says? And if this is the case, how does it happen? Everything indicates most strongly that the contractile vesicles are filled out of the vessels during the diastole. We see how, during this process, the swollen part of the vessels near their embouchure gradually or suddenly returns to its smallest diameter as the stellate figure vanishes; and I have observed a part of a vessel inflated with the fluid, originating at the extreme end of the animalcule, traverse the whole distance up to the contractile vesicle during a single diastole. This phenomenon may be supposed to show that the absorbed fluid which had inflated the vessel into a globule, flowed during the said period into the contractile reservoir.

"But if there is a fair presumption that the contractile vesicles are filled out of the vessels, the above observations teach us nothing whatever on the question as to where the fluid flows during the systole.

"I have hitherto only become acquainted with one fact relating to this point. In *Bursaria Vorticella* we may detect the following fact: as soon as the contractile vesicle which lies at the posterior end of the body has contracted, we may observe at the margins of the animalcule, in its usual position of swimming, that two long narrow cavities originate, filled with transparent colourless fluid; and these stretch from opposite the mouth as far as the region of the contractile vesicle. They both gradually enlarge, and thus approach near to the anal point; here they meet, lose their often very irregular form, and change into the globular: the remaining contents of the body are displaced upwards by this; and then these globular reservoirs contract until they vanish, without it being perceptible where the fluid has been driven to; after some time the narrow light streaks reappear, and the process is repeated in the way above described. The afferent canals, therefore, are not filled at the commencement of the systole; but must this not be so much the more expected if the fluid flowed back in the same path as it came in, the vanishing of the contractile vesicle taking place much more rapidly than its production?

"I have never yet found in any Infusorium special canals in which the fluid is seen to flow back into the body during the systole, and which would give the means of a perfect circulation."

NUCLEUS. NUCLEOLUS.—A most important internal organ remains for description, viz. the *nucleus*. This name, if not accurate, is convenient to designate the structure in question: it took its rise in the hypothesis of the unicellular nature of the Ciliata, and has ever since replaced the name "testis," or male spermatic gland, assigned it by Ehrenberg on the supposition of its being the male reproductive organ in these presumed hermaphrodite beings. Indeed, when viewed as the centre of reproductive activity, or, in Prof. Owen's phraseology, the seat of the 'spermatic force,' the Berlin naturalist's name for it does not appear so inappropriate; nevertheless no real homology can be said to exist between the testis of higher animals and this body, which, on the contrary, has several points of analogy, at least, with the nucleus of plant-cells; nor can a hermaphrodite nature be rightly ascribed to the Ciliata.

The nucleus is present in all the Ciliata, and is mostly very readily seen, unless the body is much occupied by food and opaque particles of any kind. If not at once apparent, it is demonstrable by the disruption of the body by pressure; by the process of diffluence, which disperses the surrounding tissues; or by the addition of acetic acid, which dissolves the rest of the animal, leaving the nucleus more or less completely isolated.

It occurs as a well-defined, finely-granular, more or less opaque body, having a more solid look than the surrounding parts, and frequently also a tawny or slight yellow blush (XXIX. 28 *c*, 30 *c*, 48 *c*; XXX. 1, 11 *d*, 12 *b*, 27 *f*). It varies both in position and shape in different species, and either presents one or more internal spots or small bodies of a circular outline which represent the nucleolus or nucleoli, or this organ may appear as a distinct appendage to it (XXVIII. 9–15; XXIX. 28). The nucleus is imbedded in or closely united with the cortical lamina; and although it may be thrust aside by the impetus of passing particles of food, it retains its hold. Under the usual point of view of an animalcule, its position will look more central than it really is; for it is either in advance or in rear of the real centre, or to one side or other of it, and often lies across the alimentary tube when elongated or band-like. But what is curious about this organ is, that it is not at all firmly fixed in its position, but is pushed forward or backward to one side and to the other by the movements of the animal, particularly by those of the retractile ciliary wreath, and also by the ingestion of food. This may be witnessed in *Opercularia* and *Epistylis*. Lastly, even in examples of the same species its position is not constant.

The usual figure of the nucleus is circular or oblong, but it may be clavate or reniform, or sinuous and band-like. The first type of outline prevails in *Paramecium* (XXIX. 28), *Colpoda* (XXIX. 37), *Nassula* (XXVIII. 1), *Chilodon* (XXIX. 48), *Spirochona* (XXX. 17), and *Stylonychia* (XXVIII. 10 *d*). A reniform or kidney-shaped one is seen in *Epistylis plicatilis*, in *Opercularia articulata* (XXX. 1), and in *O. berberina*; a horse-shoe figure in *Vorticella* and *Zoothamnium*; whilst in *Epistylis branchiophila*, in *Ophrydium* (XXX. 5, 6), *Carchesium*, *Trichodina* (XXIX. 16, 17), *Lagenophrys* (XXX. 29, 30), &c. it is still more elongated and band-like and much curved, or actually sinuous. Cohn represents it as having a thick clavate figure in *Nassula elegans*. The figure, moreover, is very much modified during the reproductive processes, and in the metamorphoses which befall some at least of the Ciliated Protozoa; these modifications, however, we shall not here consider, but reserve them to the details on development. Again, even among examples of the same species, slight variations occur in length and width, and in curvature or sinuosity, where no reproductive act is discernibly in progress. Lastly, not a few of the nuclei, which are at first sight simply oblong, are, on closer examination, seen to have a depression or sulcus on one side, and consequently to be, strictly speaking, bean- or kidney-shaped. This is exemplified in the nuclei of *Paramecium*, certain *Nassulæ*, and in *Prorodon*.

Where the nucleus is elongated, it is a common event to see it bent partially round the pharynx or the œsophagus, at some little distance from it.

The nucleus being the last of the soft contents to break up after death, is presumably of a more solid texture. Its tissue may be described as normally homogeneous; but various changes are ever occurring in it, rendering it at one time more transparent, at another more granular and opaque. It must owe a certain degree of resistance to external injuries to the fact that it is enclosed by a tough elastic membrane or sac, which sometimes is separated from it by a clear interspace or areola, but at other times is closely adherent, and only demonstrable by artificial means, such as the application of chemical reagents, or of a solution of potash, or of acetic acid: this happens in *Vaginicola*. When loose, this membrane not unfrequently falls into plaits or folds. It is represented in Cohn's figure of the nucleus of *Nassula elegans* as a very distinct and stout tunic.

The rule is, that the nucleus is single, and it has been assumed as a fact that the appearance of a double nucleus or of two nuclei is a general indication of the approaching or progressive act of fission. However, Stein in a recent figure of *Stylonychia mytilus* (XVIII. 10), delineated in Carus's *Icones Zootomicæ*, represents two ovoid nuclei as present without the accompanying process of self-division. In *Chilodon Cucullulus*, he also represents the nucleus (XXX. 48 *e*) to be composed of a moderately thick external or cortical portion surrounding a clear cavity, in the centre of which the opaque solid nucleolus is placed. The cortical lamina, he affirms, consists of the usual homogeneous granular substance which makes up the mass of most nuclei, but rather firmer; and its internal free surface towards the cavity is, he says, undulated or dentated. The interspace between the nuclear lamina and the nucleolus is not always clear, but occasionally occupied by a cloudy, finely-granular matter,—whence the nucleus acquires rather the characters of a homogeneous tissue, having a central, well-defined nucleolus. Although the last-named structure is probably never absent, it has nevertheless escaped Stein's notice in very young specimens. The nucleus of *Spirochona* in young specimens is either solid and homogeneous, or transversely divided into two by a crescentic space (XXX. 28 *f*); the nucleolus occupies the middle of the nuclear cavity, and has around it a finely-dotted areola (XXX. 17).

In the case of *Paramecium* both Cohn and Stein describe the nucleolus to be included in a depression or hilum on one side the nucleus. Like the nucleus it is formed of a membranous coat and homogeneous contents (XXIX. 28 *d*); the connexion between the two appears to be only by the adhesion of their membranes, an adhesion readily broken through by pressure or by the action of acetic acid. Further, in the long band-like nuclei, the nucleoli seem to be multiplied in number.

On the subject of its chemical nature, Stein concludes from the reaction of tincture of iodine, and of acetic acid with a solution of sugar, that the nucleus is a proteine compound, like the other contents, except the fat-corpuscles.

Although its office in secreting a spermatic fluid may be justly called in question (direct observation being contrary to it), yet this so-called testis, or, perhaps more correctly, this nucleus, certainly plays a most important part in the well-observed mode of propagation by spontaneous fission; for whenever fission, whether longitudinal or transverse, is about to occur in an animalcule, the first change observed is a progressive constriction of the nucleus, succeeded by that of the body generally. This constriction goes on till division is complete, each segment of the body being consequently provided with a nucleus. The division of the nucleus, as an essential element in the process of spontaneous fission, may be well observed in the transverse division of *Paramecium*, *Bursaria*, or *Chilodon*.

Professor Owen, in his learned and able *Essay on Parthenogenesis*, refers to the initiative, assumed by the nucleus of Infusoria, in their reproduction by spontaneous fission, between which and the essential contact of the spermatozoon with the germ-cell, as a preliminary to the primary process of self-division of the latter, in the course of the development of more perfect animals, he indicates an analogy; and, after having completed the comparison of the results in the two cases, goes on to say,—"This is certain, that the analogy between these phenomena in the multiplication of the parts of the germ-mass, and those of the nucleus in the multiplication of monads, is so close, that one cannot reasonably suppose that the nature and properties of the nucleus of the impregnated germ-cell, and that of the monad can be different.

"Therefore, I infer, that the nucleus of the Polygastric animalcules is the seat of the spermatic force; it can only be called testis, figuratively, it is the essence of the testis. It is the force which governs the act of propagation by spontaneous fission: and, if Ehrenberg be correct, in viewing the interstitial corpuscles as germ-cells (to which opinion Professor Owen inclines), these essential parts of ova may receive the essential matter of the sperm from the nucleus, which is discharged along with them in the breaking up of the monad, which Ehrenberg regards as equivalent to an act of oviposition; and impregnated germ-cells may thus be prepared to diffuse through space, and carry the species of Polygastric animalcules to a distance from the scene of life of the parent" (p. 67, Ed. 1849.)

Lieberkühn (*A. N. H.* xviii. 1856, p. 321) makes the nucleolus of importance in founding specific characters. He says, that, excepting the eye-point, the nucleolus is properly the only part which distinguishes *Ophryoglena flavicans* from *Bursaria flava*.—"This body," he proceeds to say, "is shaped like a grain of barley, and is marked at each end with a few sharply-defined streaks or furrows; its length is somewhat more than $\frac{2}{100}$ of a millimetre, its thickness in the middle about $\frac{1}{100}$ of a millimetre. Its substance has a stronger refractive power than that of the rest of the body, but far less than the fat-like globules. Under the highest magnifying power, no structure could be distinguished, and it withstands for a considerable time the action of water. The nucleolus is situated on the middle of the nucleus, which is about one-fifth of the entire length of the animalcule, and its breadth in the middle about one-third of its length.... It is of ovate form; its substance displays no recognizable structure.

"The nucleolus has very different characters in all the specimens of *Bursaria flava* I have hitherto observed. It was always so small that it was difficult to find it, and never became visible until the Infusorium was compressed, while in *Ophryoglena flava* it may usually be seen through the integuments. Its form is globular, and it presents no structure. It generally adheres firmly to the surface of the ovate nucleus."

The same lesson concerning the utility of the nucleus and nucleolus in distinguishing genera and species, might be gathered from the descriptions of Stein and others, which show clearly enough that these organs have a determinate figure and relation in several genera, as, for example, in *Spirochona* and *Paramecium*.

The figure of the nucleus and the relation of the nucleolus to it, in *Prorodon teres* and in *Nassula elegans*, are deserving attention. In the former species the nucleus is represented as globular, with a nucleolus surmounting it (XXVIII. 9); in the latter, the nucleus is stoutly clavate, and terminated by a small oblong nucleolus at its narrower extremity. These well-marked peculiarities in the two examples named, coupled with the views of Lieberkühn just cited, and the conclusions of Stein and Balbiani concerning the physiological relations of the two organs in question, will challenge for them much more attention than they have hitherto received.

M. Balbiani has lately contributed to the French Academy two most important papers, in which he has endeavoured to demonstrate a sexual reproduction of the Ciliata, the nucleus representing the female, and the nucleolus the male, element. In his first essay he illustrates his hypothesis by reference to *Paramecium Bursaria* (*A. N. H.* 1858, i. p. 435), and thus writes:—

"For several generations the *Paramecia* multiply by spontaneous scission, each of the two new individuals obtaining half the primitive nucleus....

But under the influence of conditions of which we are still ignorant, the species propagates itself in a very different manner, and in the midst of phenomena far more complex than those which preside over the multiplication by fissiparity. In this new mode we shall see the actual anatomical signification of the nucleus and nucleolus, the function of which, if we except the division of the former of these two organs in the act of spontaneous division, has hitherto been perfectly passive. It is, in fact, at their expense that the male and female reproductive elements which characterize this mode of propagation are formed.

"When the period arrives at which the *Paramecia* are to propagate with concourse of the sexes, they are seen assembling upon certain parts of the vessel, either towards the bottom, or on the walls. The copulation is always preceded by certain-preliminaries which are very curious to observe, but upon which we cannot dwell here. Soon they are found coupled in pairs, adherent laterally and as it were locked together, with the similar extremities turned in the same direction, and the two mouths closely applied to each other. In this state the two conjugated individuals continue moving with agility in the liquid, and turning constantly round their axis. There is nothing, before the copulation, to announce the considerable changes which are about to take place in the nucleus, and the nucleolus which accompanies it. It is during the copulation itself, of which the duration is prolonged for five or six days or more, that their transformation into sexual reproductive apparatus takes place.

"The nucleolus has undergone a considerable increase in size, and has become converted into a sort of capsule of an oval form, of which the surface presents longitudinal and parallel lines or streaks. Nearly always, it soon divides in the direction of its greater axis, into two, or more frequently into four, parts, which continue increasing independently of each other, and in a very irregular manner, and form so many secondary sacs or capsules. At a period which is still near that of division, these latter appear to be composed of an extremely fine membrane, enveloping a bundle of small, curved bacilla, extending from one extremity of the sac to the other, inflated towards the middle, narrowed towards the extremities. It is these which, when seen through the enveloping membrane, give the capsule the striated appearance which is characteristic of it, and which even exists in the nucleolus at almost all the other periods of the life of the Infusorium. It also contains a perfectly colourless and homogeneous fluid.

"At the same time the nucleus has also changed its form and aspect; it has become rounded and widened; its substance has become softer and lost its refractive power, and towards its margins it presents notches, which, penetrating more and more deeply into its mass, isolate one or more fragments, in which a sufficient magnifying power enables us to see a certain number of small transparent spheres with an obscure central point. In other cases the nucleus, whilst still almost entire, presents this aspect, and then appears as if stuffed with these little rounded bodies, the analogy of which to ovules cannot be doubted in the least. The evolution of the nucleus and nucleolus being identical and progressing at the same rate in the two coupled individuals, it follows, if from this moment we regard the former as an ovary, and the second as a testicle or seminal capsule, not only that each of them possesses the attributes of both sexes, but that they fecundate each other, and serve at the same time as male and female. As regards this fecundation itself, everything seems to prove that it takes place by means of an exchange, made by the two coupled individuals, of one or more of their seminal capsules, which pass, through the apertures of the mouths closely applied against each other, from the body of one *Paramecium* into that of the other; for, very often, although we may not be able to perceive this passage itself, we may at least detect the moment when one of the capsules already engaged in one of the mouths, is on the point of clearing this aperture. Does the exchange which causes fecundation take place with all the capsules in a single copulation, or in so many successive copulations with different individuals? This is a question the solution of which is not easy, and which, to keep within the field of our observations, we shall not attempt to solve at present.

"However this may be, each capsule, after its transmission, still continues to increase in size in the body of the individual which has received it; for we have never found any which had attained the limit of their development in individuals which were still coupled. They then frequently attain a volume greater than that of the nucleus itself; but there is never more than one that arrives at maturity at the same time. When, having arrived at this state, it is examined after being pressed out of the body of the animalcule to free it from the granulations which mask it more or less while there, it appears under the form of a large ovoid body, the surface of which presents a multitude of parallel striæ directed longitudinally, and due to the arrangement in series of the corpuscles contained in the interior. Compression, carried so far as to cause its rupture, distinctly shows it to be formed by a membrane of extreme tenuity, and contents, enclosing an innumerable quantity of small fusiform corpuscles, of which the extremities are completely lost to sight in consequence of their extreme fineness. As soon as they are free, these little bodies show themselves to be animated by a vacillatory and translatory movement, which soon causes their dispersion in the circumambient fluid. These are the spermatozoids of *P. Bursaria*. Iodine, alcohol, and acetic acid instantly stop their movements; they are insoluble in the last-mentioned reagent when concentrated, although this dissolves all the other elements of the body, with the exception of the green granules.

"It is usually from the fifth to the sixth day following the copulation, that the first germs are seen to make their appearance, in the form of small rounded bodies, formed of a membrane which is rendered very evident by acetic acid, and greyish, pale, homogeneous, or almost imperceptibly granular contents, in which neither nucleus nor contractile vesicle is yet to be distinguished. These organs do not appear until afterwards. The observations of Stein and F. Cohn have shown how these embryos quit the body of the mother in the form of *Acinetæ* furnished with knobbed tentacles—true suckers, by means of which they remain for some time still adherent to the mother, deriving their nourishment from her substance; but their investigations did not reveal to them the ultimate fate of these young animalcules. I have been able to follow them for a considerable time after they detached themselves from the body of the mother, and have convinced myself that, after losing their suckers, becoming surrounded with vibratile cilia, and obtaining a mouth which first shows itself in the form of a longitudinal furrow, they definitely acquired the form of the mother, becoming penetrated in the same way by the green granulations characteristic of this *Paramecium*, without undergoing any more important metamorphoses."

At the time this first record of his observations was read, M. Balbiani stated that he had collected them from the investigation of six or seven species, but since that period he has pursued his observations in several other species, and completed some old ones previously interrupted from want of materials (*A. N. H.* 1858, ii. p. 439). In his latest paper, he enunciates the remarkable statement that he has been led to regard, in a great number of cases, what nearly all authors have considered to be a spontaneous division in a longitudinal direction, as a sexual union of two individuals. "Very often, in fact, I have been able to ascertain that this state coincided with certain remarkable changes which took place in the internal organs of these animals."

The following is the general summary of the results M. Balbiani has arrived at:—"I. The corpuscle which, in the Infusoria, has been described under the name of nucleolus, and which I have shown to be the male genital gland, has hitherto only been indicated in a few rare species. In connexion with this, I have examined a great number of individuals belonging to numerous and varied forms, and I have convinced myself that, far from constituting an exception, the presence of one or even several nucleoles was a nearly constant fact in the different types of this class; but frequently the simple or multiple nucleole which they contain is so intimately confounded with the substance of the nucleus, that it only becomes apparent when it is separated therefrom accidentally by the action of reagents, or spontaneously at certain determinate periods in the life of these creatures, principally at the time of their sexual propagation. I have counted fourteen species in which this organ was very evident to me, and in which I have also been able to follow its evolution, to a greater or less extent, at the breeding-season, at the same time that I was an eye-witness of the other actions which concur in assuring the reproduction of these animalcules by fecundated germs.

"As regards the number and situation of the testicular organ of the Infusoria, I have met with the following varieties. It is simple, rounded, and lodged in more or less deep depressions of the nucleus in *Paramecium Aurelia* and *P. caudatum*, and also in a third species, nearly allied to *P. Bursaria*, but smaller and destitute of green granules. The genus *Bursaria* (*B. leucas*, *flava*, and *vernalis*) also presents a simple nucleole situated in the vicinity of the nucleus. The same thing occurs in *Chilodon Cucullulus*. But with regard to the latter, I must remark that I do not regard as the analogue of the nucleole of the preceding species the corpuscle to which M. von Siebold has given this name, and which is placed in the interior of the granular mass of the nucleus, in the centre of a broad transparent zone. The true nucleole or testicle of *Chilodon* appears in the form of a small, rounded, brilliant grain, provided with a proper membrane, and situated quite to one side and towards the middle of the nucleus. It is very easily perceived in large specimens by employing the action of reagents. As regards the nucleus and its internal parts, I make no difficulty in regarding them as representing all the elements of an ovum, of which the nucleole of the celebrated German naturalist would be nothing but the germinal spot. The disappearance of the clear zone and of its central corpuscle in the animals which have just copulated, especially appears to me to militate in favour of this view.

"II. I have met with a multiple testicle in many species belonging to the groups of the *Oxytrichinæ* and of the *Euplotes* or *Plœsconiæ*, including the highest types of this class. In the genus *Oxytricha* the two nuclei, which are elongated in the direction of the greater axis of the body, are each accompanied by a small, rounded, testicular body, very distinct from the corresponding nucleus. There are also two, placed one to the right and the other to the left of the long nucleus, which is curved into the form of a horse-shoe, in *Euplotes Charon* and *E. viridis*. In the genera *Stylonychia* (*S. Mytilus*, *pustulata*, and *lanceolata*) and *Urostyla* (*U. grandis*) the nucleoles, to the number of four or five, are distributed in two groups in the vicinity of the nuclei, of which the anterior is accompanied by two, and the posterior also by two or sometimes three, of these little organs. They are remarkable from their distinctly-rounded outline, their great refractive power, and their homogeneous structure. In *Spirostomum ambiguum*, each of the grains of the long moniliform cord which here replaces the oval nucleus of the other species, gives lodgment, in a deep depression of its surface, to a small rounded corpuscle, which corresponds with the nucleole of the preceding species; this brings the number of testicles in this animal to forty-five or fifty. I have only been able to perceive them in individuals which have been copulating for a certain time, and by employing dilute acetic acid. It is very probable that an analogous arrangement will be found in the other types, in which the nucleus is formed of grains placed in a single row, like a necklace, such as *Stentor, Kondylostomum, Trachelius moniliger*, &c.

"III. The evolution of the male genital apparatus of the Infusoria, as just characterized, in the other species of the genus *Paramecium* does not differ from that presented to us by *P. Bursaria*. In the *Oxytrichina* each of these organs remains entire, becomes enlarged, and exhibits in its interior, applied against its wall, a thick granular body, furnished with a tubular appendage, which projects into the cavity of the capsule, and appears to be open at its free extremity. This tube, which seems to be an excretory duct, often appeared to be filled with capillary filaments of extreme fineness, arranged parallel to the axis of the duct in question, in which they were fixed by a portion of their length, whilst the remainder, escaping by the orifice of the tube, radiated in all directions in the interior of the capsule. Subsequently the granular body and its duct disappear, and the filaments, becoming free, collect into a bundle, which fills the whole of the formative sac. Although I have never seen them execute any movements, I do not hesitate in considering them as the spermatic filaments of these animals.

"IV. It is with equal certainty that we may call the *nucleus* the female genital organ of the Infusoria, in opposition to the perfectly hypothetical assertion of Ehrenberg, who regards it as the testicle. Its evolution likewise only commences at the time of reproduction, and often during the sexual union itself. In *P. Aurelia* and *P. caudatum*, towards the end of the copulation, its surface is traversed in all directions by numerous furrows, which, penetrating deeper and deeper into its mass, finally divide it into a great number of unequal and irregularly-rounded fragments, having a clear centre more or less surrounded by granules. I should compare these with the first rudiment of a vitellus, and the transparent central portion to a more or less developed germinal vesicle. The fragments thus formed are soon dispersed in the surrounding parenchyma. Here a very small number of them, almost always four, never more and very rarely less, complete their evolution, and soon acquire the appearance of complete and well-developed ova. In this state they present themselves in the form of small brilliant bodies, perfectly equal in volume, slightly oval, and of a bluish-grey appearance. We may very clearly distinguish in them a finely-granular vitellus, surrounded by its proper membrane, which separates from it more or less after a few moments' exposure to water. The germinal vesicle and spot are also visible with a distinctness truly surprising, considering that we have to do here with the smallest of living organisms. I have met with these ova still enclosed in the body of the animal on the seventh day after the copulation: they no longer exhibited either germinal vesicle or spot; and their volume had slightly increased. In the allied species, *P. Bursaria*, the reniform nucleus becomes unrolled before breaking up, and in this state resembles the ribbon-shaped nucleus of the *Vorticellæ*. About twenty or twenty-five of the fragments produced from it continue their development and become so many perfect ova. In the nucleus of *Chilodon Cucullulus*, also, we observe, after the copulation, the disappearance of the transparent zone with its central obscure spot. In the genera *Stylonychia* and *Urostyla* the ova are four in number, as in *Paramecium caudatum*, but they are produced by a different mechanism. Each of the two nuclei divides into two halves, as in the act of spontaneous division; and the four fragments thus produced form an equal number of perfect ova. Lastly, in *Spirostomum ambiguum*, we have seen, in individuals which have been copulating for some time, the forty or fifty grains of the long flexuous cord which traverses the body become rounded and detached from each other. But we have been unable to discover in these all the characters of an ovum with the same distinctness as in the preceding species, no doubt because they had not yet arrived at their complete development.

"V. I have not witnessed the *deposition of the ova* in these animals. It is very probable that they escaped by the anus, or by some neighbouring aperture. Thus, in the *Stylonychiæ*, I have seen them collect in the posterior part of the body, which bears the anal orifice, and diminish gradually in number from the first or second day after the copulation. It is a singular thing, that about this period a round pale body begins to make its appearance in the centre of the animal; this becomes constricted about the middle, and reconstitutes the double nucleus of *Stylonychia*.

"VI. The Infusoria are destitute of copulatory organs. In most cases the copulation is effected by simple juxtaposition, the two mouths establishing the sexual communication (*Paramecium, Bursaria, Euplotes, Chilodon, Spirostomum*). In the *Oxytrichina* the union is more intimate, and goes so far as to constitute a true soldering of the two individuals for more than two-thirds of their anterior part. Any one who had not witnessed all the phases of this singular copulation, would be unable to avoid regarding this state as a longitudinal division, proceeding from behind forwards, in a single animal. But, even if direct observation were wanting, the concomitant changes of the internal organs, which are so characteristic, cannot leave the least doubt as to the actual signification of this act."

OVULES.—In Ehrenberg's organology of Infusoria, ovules or ova assumed a high importance. The structures he so designated had no distinctive features assigned them, whereby they could be distinguished from other corpuscles and granules in the interior; and, in consequence, their existence could not be confirmed by other microscopists, who for the most part declared that the supposed ova were indifferently alimentary vacuoles, particles of food, fat globules, or the ordinary granules of the interior. The general opinion became pronounced against the very existence of ovules and of development by their means, whilst the deposition of ova, which Ehrenberg believed he witnessed in several instances, was explained to be an act of diffluence misconceived. This explanation, for instance, has been given to his recorded observation and his figures of the act of oviposition in *Colpoda Cucullulus*, which represented this animalcule as bursting and giving vent to strings of ova, which first ran together in a reticulate manner, and then, after a time, became individually developed into young *Colpodæ*. According to the opposite view, the bursting and extrusion of contents are no other than the phenomena of diffluence and the dispersion of particles of sarcode, whilst the young supposed to originate from those particles are merely minute Monads or monadiform corpuscles found in company with the *Colpodæ*.

One objection brought against the assumption of ova being ejected from Protozoa in the exercise of a generative function is certainly frivolous—viz. that the empty or broken shells of the ova ought to be met with; for the shell of an egg, however useful in larger animals as a defence against injury, is no essential part of an ovum from which a new being can be developed.

Although the existence of ova among the Ciliata has been denied by the great authorities on Infusoria—by Kölliker, Siebold, Leuckart, Cohn, Stein, Van der Hoeven and others, yet it has latterly found two advocates in Prof. Perty and Mr. Carter. The latter writer (*A. N. H.* 1856, xviii. p. 225) can adduce little direct evidence to support his views, and seems to rest more weight upon argument from analogy with *Amœbæa*, *Arcellina*, *Astasiæ*, and *Euglenæ*, in all which he has satisfied his own mind of the presence of ovules, and of their development in the two latter genera. "The same kind of development," he writes, "of the ovule probably takes place in all the Rhizopoda as in *Spongilla* and in *Astasia* and *Euglena*:" but this is not proving that Rhizopoda are developed by ova; and the entire value of the presumed analogy with *Astasiæ* depends on our admitting a natural affinity and close similarity in organization between that family and Ciliated Protozoa, on the one hand, and Rhizopodous Protozoa on the other. Indeed, we imagine the prevailing opinion to be, that the history of development of *Astasiæa* corresponds rather with that of vegetable organisms than with that of the Protozoa; for this so-called ovular reproduction of the *Astasiæa* certainly seems analogous with the development of zoospores in many unicellular Algæ.

To recur to Mr. Carter's statements, he tells us he applies the term "ovules" to "a number of discoid or globular nucleated cells, which appear together in the sarcode of some of the Infusoria;" and he subsequently proceeds to uphold his views by his own personal observations, and by inferences drawn from others. "In many of Ehrenberg's enterodelous Infusoria it is not uncommon to see a number of defined globular bodies, of nearly equal size and of a faint opaque yellow colour, which closely resemble ovules—*e. g. Amphileptus fasciola* (Ehr.), *Himantophorus Charon* (Ehr.), &c.; nor is it improbable that many of his Trachelina, which come near *Planaria*, possess ovules similar to those which are found in the latter; but, from being so much mixed up with the spherical cells, pass equally unnoticed while in, as well as when out of, the body, under such circumstances. M. J. Haime, however, has distinctly seen instances in which these bodies have been ejected from Infusoria, and have passed into locomotive animalcules under his eye. Thus he states that in *Plœsconia* they form a group of from forty to fifty in the middle of the body, are round, issue one by one, remain tranquil some time, then develop two filaments, one in front, the other behind, and move about rapidly. In an 'undescribed' species of *Dileptus* they are whitish, and form a wreath extending almost throughout the whole length of the body, become yellow towards the anal extremity, where they pass out with the remains of the food, soon develope two opposite filaments, and move about rapidly. In *Paramecium Aurelia*, M. Haime states that an ovary appears some hours before death, about the middle of the body, which becomes filled with about sixty little nuclei: these increase in size, burst the ovisac, and thus pass into the body of the parent, from which they finally escape by an opening in the tegumentary covering, formed by the diffluence of the latter; and the ovisac follows them."

Perty has used great diligence in searching for the presence of ovules or, more accurately, of *germs* (Blastien), and has adduced various arguments for their existence. He states (*op. cit.* p. 66) that their aspect is distinctive, although their colour varies in different species, that, unlike food, they retain their form, increasing only in size, and that, on the dissolution or breaking up of the animalcules, they display themselves as free individualized structures. It is only, he adds, in incomplete forms, in young and imperfect beings, that any doubt can exist respecting the character of these corpuscles. Ovular development does not take place as Dujardin surmised, by detached morsels of the sarcode, nor by ova such as Ehrenberg supposed, but by a peculiar set of bodies, originating in the interior of the animals, and progressively multiplied. Their minuteness is a bar to observation; and it is only by the concurrence of favourable circumstances—by the presence of the ovules in their first, intermediate, and finished stages—that they can be satisfactorily made out, as in *Nassula aurea, Euglena viridis, Chonemonas bicolor*, &c. Fission may be several times repeated; but the formation of germs takes place at the expense of the contents of the parent.

The unusually small size of many animalcules is another argument advanced in favour of propagation by germs or ova, since the act of fission is limited to a certain size, and the natural characters of the species are to be preserved. Thus Perty met with examples of *Kerona pustulata* as small as 1-70‴, which could scarcely originate from fission. They were exactly like the original animalcule except in being more round. Specimens of *Pleuronema crassum* occur no larger than 1-90‴, devoid of molecules, more transparent and slender than old ones, with a more pointed apex, but otherwise their counterpart. Again, *Nassula aurea* varies from 1-150‴ to 1-12‴; and in those of 1-50‴ the rudiments of the "dental" apparatus are distinguishable. An *Amphileptus moniliger*, 1–6‴, having a very short neck, was distended by 100–150 germs or ovules surrounded by some thousands of fine molecules; that these were neither vacuoles nor stomach-sacs was seen at places where they displayed themselves as individualized corpuscles. Moreover there were no other animalcules or particles of food in the glass containing the *Amphileptus*, and all the germs were uniform in size, in hue, and in refractibility, and readily distinguishable from some swallowed Infusoria present in some spots. The green spheroidal corpuscles in *Paramecium versutum*, having a medium size of 1-450‴, are true ovules: they do not change colour, like the green nutritive matters of Infusoria, to yellow, red, or brown; and when the animalcule is left dry by evaporation, they become isolated. Although no germinal speck is discoverable in these bodies as in ordinary ovules, yet it is remarkable that a fold, streak, or darker space is visible. Small specimens of this Infusorium also occur in which the ovules are colourless or pale green; and on one occasion Perty saw, amid the fully-developed individuals, oval greenish animalcules of about 1-60‴, which seemed no other than the escaped germs of the *Paramecium*.

Such are some of the principal observations Perty appeals to in order to substantiate his hypothesis of internal germs and of development from them. He has given, in illustration, a number of figures; but they are too rudely drawn to efficiently answer their object; and we must confess our inability to receive the fact of the existence of ova or germs as at all demonstrated in the Ciliata either by the researches of Mr. Carter or of Perty. The discoid or globular nucleated cells which the first-named writer makes out so clearly in the *Astasiæa*, are merely supposed to be represented by certain "defined globular bodies of nearly equal size and of a faint opaque yellow colour, which closely resemble ovules" (why?), not uncommon in many ciliated Protozoa, *e. g.* "*Amphileptus fasciola, Himantophorus Charon*, &c." Such evidence is purely presumptive, and is little aided by M. Jules Haime's anomalous observations. Respecting Perty's arguments and reported phenomena, it may be objected that he does not establish his attempted rigorous description of germs —does not show their distinctive peculiarities as stated, and seems to have confounded together various internal bodies in his description of germs. Thus in the *Paramecium versutum* (which he presumes to be the same animalcule described by Cohn as *Loxodes Bursaria*) the green spheroidal corpuscles look to be nothing more than the chlorophyll globules pointed out by Cohn and Stein. Again, of the ambiguous corpuscles in other Protozoa cited as ovules or germs, it is simply from their doubtful character that this can be presumed; for our knowledge of the contents of the Ciliata, of the changes they may visibly undergo from the action of external agents, from age, and other conditions, is at present too imperfect to signalize certain particles, definable by no sufficient characteristics, as special structures, such as ova,—unless, indeed, we can watch their origin, growth, extrusion, and development into animalcules assuming the particular form and organization of the parent animal at an earlier or later date. Perty, indeed, has imagined—not proved—certain minute organisms floating in the vicinity of an animalcule, having about the same size as the supposed internal ovules, to be the young resulting from those germs; and although it cannot be denied that he is in the right, yet it is for him to show that he is so, by elucidating the phases of development; and we must always keep in view the very erroneous fancies which result from these supposed relations between contiguous organisms, very probably only accidentally brought together,—of which we have an illustration in the visionary hypotheses of spontaneous development and ascendant embryogeny put forth by Gros and others.

We have stated the preceding objections against the particular statements of Carter and Perty, and not against the hypothesis of the production of internal germs; for sufficient examples are on record of the production of such germs and of living embryos within animalcules, after preparatory developmental changes, from the fission and breaking up of the nucleus. Before leaving this hypothesis of the existence and development of internal germs, it is but right to mention that it has been received, among others, by Eckhard and by Oscar Schmidt, both of them supporters, in almost all their details, of Ehrenberg's views, and who are believed by most authorities to have too much the character of advocates of a particular theory, to discuss or to observe in general without prejudice. To allude briefly to their observations, Eckhard (*A. N. H.* 1847, xviii. *Suppl.* p. 446) in the first place remarks, as others have done, on the very different sizes of animalcules of the same species, as a proof of ovular development, arguing that the very smallest cannot result from fission or gemmation. To this he appends an observation made on *Stentor cæruleus* (XXIX. 8), which, from its completeness and apparent truthfulness, deserves quotation when we come to speak of the development of ova. Schmidt corroborates Eckhard's statement of the production of living germs from *Stentor cæruleus*, and affirms, in addition, that germs are frequently extruded and developed outside the parent, and that their subsequent development from minute globular and conical transparent and almost colourless organisms, with long cilia, may be watched through all the intermediate stages until the complete animalcule, with its spiral ciliary wreath and mouth, is perfected.

The preceding speculations on the development of ovules and germs have their importance materially modified by M. Balbiani's recent researches and hypotheses respecting the prevalence of a sexual mode of reproduction among the Ciliata, as detailed above (pp. 329–334).

Spermatozoids (?).—This term is provisionally applied by Mr. Carter to granules originally developed from the nucleus in *Amœba*, *Euglypha*, and *Spongilla*, and supposed by him to impregnate the ovules. "With reference to the organs of generation," he writes (*A. N. H.* 1856, xviii. p. 228), "in the other Infusoria, I can state no more than that, although there is a fusiform nucleus in *Otostoma* (XXVIII. 25, 26), I have also constantly seen a bunch of string-like filaments floating about its interior, which appeared to be attached near the buccal cavity; and although I could make out nothing more, I could at the same time only liken these to the generative apparatus in the *Planaria* mentioned, which floats round the buccal cavity and upper part of the membranous stomach in a similar manner."

The notice of Mr. Carter, of the peculiar structures he would designate spermatozoids, is as yet unconfirmed by other writers; and we must therefore consider their nature and purpose still *sub judice*.

Since the above was written, M. Balbiani's researches (*A. N. H.* 1858, vol. i. p. 435) confirm Mr. Carter's opinion so far as relates to the development of spermatozoids or male reproductive elements, but refers their origin to the nucleolus instead of the nucleus. In our history of these last-named organs, we have presented M. Balbiani's views, and must here refer back to them (p. 329).

ACCESSORY CONTENTS:—GRANULES; MOLECULES; SPHERICAL CELLS; SUPPOSED GLANDS.—Among the remaining contents of the Ciliata are numerous granules, molecules and fat-cells. Mr. Carter (*A. N. H.* 1856, xviii. p. 121) makes a distinction between granules and molecules—two terms which by others are very loosely used and not specially defined. This writer, however, would restrict the term molecules (moleculæ) to colourless granules more minute than those he understands by the latter appellation. "They differ in size, and are the first bodies that appear in it (*i. e.* the sarcode).... By the time the ovules have become fully formed, the sarcode and its moleculæ have died off or disappeared."

The granules "make their appearance among the moleculæ, and are circulated round the abdominal cavity in the manner of the digestive globules and particles of food. They are of different sizes, but chiefly characterized by being much larger than the moleculæ, few in number, of a circular, elliptical, elongated, subround, or irregular shape, with thick dark edges, apparently produced by obstruction to the passage of light,—colourless, or of a yellowish-green tint. When large, and with no other granular matters present but the moleculæ, they form a striking feature in the interior of *Amœba*, *Vorticella*, *Oxytricha*, *Paramecium Aurelia*, &c.; but at times they are so insignificant in size as to be undistinguishable from the moleculæ, even if present at all. That they are not ovules may be satisfactorily seen when both are together,—the dark, thick, and frequently irregular edges and colourless state of the former contrasting strongly with the thin circular margin and faint yellow tint of the latter. They appear to increase in size and number with the age of the Infusorium, and, when fully developed, to remain unaltered in size, though apparently somewhat shrivelled in form, until their dissolution. On one occasion, while watching the metamorphosis of an *Oxytricha* (similar to, but not the same as, that described by M. Jules Haime, and of which I hope to give a detailed account hereafter), these granules, during the formation of the globular cell within the body, which enclosed the materials from which the *Plœsconia* was ultimately developed, became congregated together at the posterior extremity of the *Oxytricha*, and remained there in a roundish mass, shut out from the cell, until the latter burst for the liberation of the *Plœsconia*, when, with the deciduous coverings, they passed into dissolution. Of the nature of their office I am ignorant; but they are sufficiently remarkable and constant to demand particular notice."

Perty speaks of molecules and granules together, and expresses his opinion that some are simple fat-corpuscles, and others the first rudiments of internal germs or ovules. Stein also carefully distinguishes fat-granules from others not fatty. In *Opercularia*, *Epistylis*, and allied genera of *Vorticellina*, this observer points out that no particles of food penetrate to the posterior extremity, where its diameter is narrowed to unite with the stem, but that this region is occupied with a heap of large fat-corpuscles and of minute granules of probably the same nature. Isolated corpuscles resemble precisely the fat-particles scattered through the body. He cannot assent to Ehrenberg's proposition, that this heap of granules represents a sort of loose ovary, but would consider it to be a store of nutritive matter specially intended to furnish the material required in the construction of the stem.

Under the name of "*spherical cells*" Mr. Carter (*op. cit.* p. 124) describes some special structures, which, so far as we know, are not mentioned by any other observer. "They abound," he writes, "in the sarcode of *Otostoma* (XXVIII. 25, 26), and apparently in many of Ehrenberg's 'Allotreta.' In *Otostoma* they are of different sizes, because they are in all stages of development; and to keep up their numbers without distending the animalcule, they must be continually undergoing rapid decay as well as reproduction. The most remarkable feature in them is, that the largest contain, besides other granular bodies, several small cells filled with a yellowish-brown fluid; and these cells are also found free among the general group; but of what their ultimate destination is, as they do not appear to grow larger, or to become reproductive, we know nothing." On comparing these cells with those seen in the stomachs of *Planariæ* and Rotifera, Mr. Carter concludes that they are homologous with them, and represent a biliary secreting organ. "Although," he adds, "ovules may occasionally issue together with these cells from *Otostoma*, &c. as well as from the *Planariæ*, yet the two can hardly be confounded."

On the correctness of this description we have no means of deciding: the genus *Otostoma* has not fallen under our observation; and the figures to illustrate these spherical cells convey no clear conception of their characters. We might hazard the conjecture that these supposed definite cells are only globules of food; for we are scarcely prepared to admit the existence of hepatic cells in the simple tissue of Protozoa, between which and the complex organization of Rotifera, with their true membranous stomach, so wide a difference subsists that no true homology can obtain.

Perhaps the coloured "spherical cells" of Mr. Carter are identical with the yellowish and brown vesicles Perty (*op. cit.* p. 53) separated from *Nassula aurea* by crushing it between the glass slide and cover, from $\frac{1}{6000}'''$ to $\frac{1}{1000}'''$ in size, and which he concluded to be fat-globules, and only another stage of development of numerous smaller white corpuscles he met with in the same being.

Stein has established the existence of a pair of oblong or reniform solid glandular-looking organs a little beneath the peristom of *Opercularia articulata* (XXX. 20), the purpose of which cannot be surmised. Lachmann has hinted at the possibility of their being nervous ganglions, but nevertheless feels quite unable to express an opinion.

The chlorophyll-corpuscles, chiefly confined to the soft subtegumentary lamina, have already been spoken of (p. 297), and need no further notice, except it be to recall an opinion of Cohn, that the coloured masses, called by Ehrenberg ciliary glands, seen in a few species of *Nassula*, are probably of the same nature as those corpuscles.

CIRCULATION OF CONTENTS (XXIX. 25).—The remarkable phenomenon of the circulation or rotation of a portion of the contents, similar to the cyclosis in the cells of many plants, is witnessed in most of the Ciliated Protozoa. It had attracted the notice of several observers before Ehrenberg published his great work in 1838, and was very speedily urged in argument against his views of polygastric organization, to which, indeed, it seemed fatal, inasmuch as such a rotation is clearly incompatible with the existence of stomachs attached to, and connected together by, a fixed intestine. To meet the objection thus raised, the Berlin professor suggested that the apparent circulation was abnormal, or a diseased condition, the consequence of an over-distension of one stomach-sac at the sacrifice of others, an explanation quite inadmissible, since the phenomenon is one to be very frequently observed in animalcules evidently in full functional activity and uninjured, and because the particles of food entering the interior assume their usual globular form (*i. e.* acquire the characters given by Ehrenberg to his so-called stomach-sacs), take their usual course, and do not accumulate in a confused manner within a large sac, such as the supposition in question implies.

Microscopists are now agreed in representing this rotation to be confined to a layer or stratum of the contents within the subtegumentary or cortical lamina, and not to extend to the central portion, as Cohn represented (*Zeitschr.* 1851, p. 265). The current is from left to right, as we look down upon the animalcule (XXIX. 25) under the microscope, and therefore is actually the reverse, or from right to left, with regard to the animal itself. It never changes its direction or course; but its rapidity varies in different species, and even in the same species under different circumstances affecting its vitality: such are, among external conditions, light, air, warmth, and food; others, age, the encysting and reproductive acts. Cohn observed that some particles in a *Paramecium Bursaria* occupied 1½ to 2 minutes in making the circuit. In *Vorticella* the current is slower. The stream is composed of a thin mucilaginous matter, bearing in it numerous granules and molecules, fat-corpuscles, globules of food (the stomach-sacs of Ehrenberg), and the remnants of alimentary matters in their passage to the discharging outlet. The chlorophyll-corpuscles of the cortical layer, the nucleus, and the contractile vesicles are not involved in the current, unless, indeed, a few of the first named when accidentally detached from their matrix. The nucleus lies more or less within the stream; and although moveable to a considerable extent at times by the onward pressure of a bolus of food, it yet seems to maintain a connexion with the subtegumentary lamina, and to escape being drawn into the rotating current. Further, in the large *Vorticellina*, such as *Epistylis* and *Opercularia*, the mass of fat-corpuscles at the base of the body does not join in the current; and it must be noted that the food-globules do not circulate until they have lost the independent motion received by them on their propulsion from the extremity of the œsophagus.

The most correct view, in our opinion, of the nature of the rotating stream, is that of Lachmann, who conceives it to be the nutritive fluid elaborated from the food,—in a word, "chyme." Such a fluid, analogy suggests to be needed by the cortical and sarcode laminæ over which it spreads itself, to supply material for their renovation and rebuilding, and to compensate for the constant waste consequent on the perpetual movements of the animal. And may we not further presume that this current also serves to bear away from the lamina effete particles prior to their elimination, just as the blood of higher animals serves both as a pabulum to the tissues and a channel for the removal of their worn-out material? Moreover, this circulation of a nutritive fluid around the inner layer of the animalcule has its analogy in the rotation of a similar fluid around the general abdominal cavity of the Cœlenterata, such as the Hydrozoa and Actinozoa.

Respecting the cause of this rotation of the contents, several explanations have been broached. Some seeing in it a close similarity to the cyclosis of plants, have attributed it to a like cause; but what this is in vegetable cells is anything but certain. According to some, the nucleus of the plant-cell is the exciting force, since the stream seems to set out from and to return to the nucleus; but this is not universally the case. Others, again, imagine cilia to cover the interior of the cell-wall—but this is only an hypothesis,—whilst others find in the functional activity of growth and nutrition, coupled with the co-ordinate actions of light, heat, and chemical affinity, a sufficient cause for the phenomenon. This last view comprehends the interpretation Stein puts upon the movement in question in the Protozoa, which is, that the chlorophyll-globules by their action on light, by the exhalation of carbonic acid gas, and the resultant chemical forces developed, produce the revolving movement; for, as he remarks, the movements of the animals have nothing to do with the rotation, as some have suggested, seeing that it goes on when they are in perfect repose; and moreover is seen only in those rich in chlorophyll, and not in colourless individuals.

In elucidation of chemico-vital action as a motor force, we may allude to vegetable physiology, which teaches us its power in the circulation of the sap through the appointed channels in the leaves and thence downwards through the inner bark. But, apart from the influence of chemico-vital forces, we cannot exclude the idea that the propulsive force of the œsophagus, in impelling food or water into the general cavity, must aid the current, even if its axis do not precisely correspond with the course at the point where it is first operative, since, from the difference in the arcs described by the course of the stream and by the œsophageal current, the two must eventually become coincident and concurrent.

In a recent letter to us, Dr. Strethill Wright remarks that "in *Carchesium polypinum* active molecular movements may be detected throughout every part of the zooid (animalcule), even in the thickened rim upon which the cilia are placed. This movement seems to be distinct from the rotatory motion of the whole contents of the body, so readily seen in *Epistylis grandis*, and which only occasionally occurs in *Carchesium*. The zooids of the class of Protozoa seem to be composed of sarcode in its most fluid state, enclosed in a delicate contractile coat. In this sarcode a desultory circulation occurs, either as molecular motion or as steady rotation, or as a backward and forward flowing occasioned by change of shape in the body, as in *Ophrydium versatile*."

THE ENCYSTING-PROCESS IN THE CILIATED PROTOZOA (XXVIII. 6, 7, 66, 67, 74–76; XXIX. 18, 19, 21–23, 39–46, 52–58).—Although the encysting-process is very frequently associated with the act of reproduction, yet it is also concerned with the preservation of individual life, and, so far, deserves consideration apart from the former. Were it not for some provision against such a contingency, animalcular life would be exposed to wide-spread destruction by the change of seasons, by the drying up of the pools and ditches they inhabit, and by other injurious external influences. Such a provision is made by the act of encysting, which enables these minute animal organisms at all ages to resist those destructive agencies, and also provides for their almost unlimited diffusion. The construction of sheaths around animalcules is another protective act (see p. 282), but differs from encysting in not completely enclosing them.

When an animalcule is about to encyst itself, its movements become less active, and presently cease; at the same time it withdraws and folds up its rotary or other prominent process, closes its oral aperture and contracts itself in a more or less spherical shape, and its cilia disappear. Having proceeded thus far, an excretion is thrown out around, which gradually hardens, assumes a membranous form, and invests the animalcule as a cyst or case. It may happen that the construction of the cyst commences before the animal is quiescent, while it still moves slowly about or revolves on itself by the outpouring of the soft gelatinous matter out of which it is to be elaborated, as is seen in *Amphileptus* (XXIX. 19), *Colpoda* (XXIX. 35—43), and *Chilodon* (XXIX. 48–58). Moreover, after the animalcule is enclosed within its case, it may for a time vary its figure, and also turn on itself with more or less activity, by means of its cilia, which yet remain apparent. Stein mentions this phenomenon in *Stylonychia pustulata* (XXIX. 18), and in the encysted embryos or gemmæ of *Colpoda*; and we know that similar movements precede its revival from its quiescent condition in all cases.

The cyst-wall is, at least in some examples, double, consisting of an outer, finely-granular, softer layer and an inner, consistent, elastic, homogeneous membrane (XXIX. 21, 22, 41, 43). It may be that two such laminæ always exist; for the outer one crumbles away so soon as the enclosed animal prepares to reassume its activity, and it is after the onset of internal changes that most observations have been made upon cysts. The two coats were remarked by Auerbach (*Zeitschr.* 1854, p. 431) in *Oxytricha Pellionella* (XXIX. 21-23); by Stein in *Chilodon Cucullulus* (XXIX. 53, 54), in *Stylonychia pustulata* XXIX. 18), and in *Nassula ambigua*; and by Cienkowsky in *Nassula viridis* (XXVIII. 67), &c. In *Chilodon*, indeed, Stein represents several concentric layers to the cysts (XXIX. 55, 56), and states that in this instance the walls acquire no firmness, but remain soft and gelatinous.

Another peculiarity attaching to cysts in some species, is, that they produce folds or plaits on their surface, and therewith acquire an apparent angular outline, as Stein exhibits in his figures of encysted *Epistylis plicatilis* and *E. branchiophila*, where the lines are longitudinal, and in encysted *Opercularia berberiformis*, where they are transverse or annular.

Again, the cyst-walls are not always smooth: thus, in *Nassula ambigua* Stein represents them as *punctate* in longitudinal lines; in *Stylonychia pustulata* (Müller's *Archiv*, 1856, iv.; *A. N. H.* 1857, xix. p. 228) they have stellate markings, and in a small undescribed species of *Epistylis* a finely-shagreened surface.

The changes which the encysting animal itself undergoes have been mentioned generally; but a few more details, aided by reference to particular examples, are required for a more complete elucidation of them. So soon as the animalcule becomes quiescent within the sac secreted around it, the cilia which covered the surface, including any of larger dimensions disposed along certain tracts, or upon particular processes, disappear, and have generally been presumed to be destroyed; however, various observations are on record which seem to show that this is not universally the case, but that not unfrequently they are merely concealed from view; and this being so, it becomes questionable whether—especially in the ordinary process of encysting, where only the conservation of the individual is intended—their destruction or absorption is the rule. An observation of Stein may be quoted on this question:—An encysted *Chilodon Cucullulus*, after developing several embryos, ceased this process of propagation, redisplayed its cilia as if by simple evolution, and commenced moving within its cyst along with one of its embryos (XXIX. 58). The inference deducible from this particular observation in the case of the encysting-process, even when exercised for the distinct purpose of generation, is greatly strengthened by the oft-repeated observations of the release of the imprisoned beings, by pressure causing the rupture of the newly-formed cyst, in the possession of their complete figure and their ciliary armature. We may add that no proof exists of an actual new formation of cilia upon beings when emerging from their cyst; all that can be predicated is, that cilia reappear in their normal positions and arrangement.

To sketch now the history of the encysting-process by a reference to some of the many examples recorded by various microscopists; for the act has been witnessed in so many species and genera, that it is assumed to be common to all. The description given by Cohn (*Zeitschr.* 1853, iv. p. 267) of the encysting of *Trachelius Ovum* may be given as an example (XXIX. 19, 20):—The movements of the animalcule become slower, and before ceasing altogether, consist in a simple rotation without change of position. The cilia are next seen to become indistinct and to disappear; and a delicate line, removed some little distance from the periphery of the enclosed animal, makes its appearance, indicating the limit of a soft gelatinous envelope. Whilst this proceeds, the animal assumes a more globular and contracted figure, chiefly by folding down its lip- or trunk-like process upon its general surface. The secreted covering in the meanwhile gains in firmness, but loses in thickness, and thus acquires the character of a membrane, which closely invests the *Trachelius*, except at places where the two surfaces are separate and distinct.

This may be termed the first degree of encysting, and affects the creature so slightly that it can shake off its coating of its own accord, and, by rupturing its sac, reassume its pristine appearance and activity. This phenomenon was witnessed four times in the same individual by Cohn, and supposed by him to have been induced by the abnormal conditions (the action of light, &c.) in which the animalcule was placed under the microscope. Stein (*op. cit.* p. 133) in a similar manner recounts the formation of a cyst around *Chilodon Cucullulus*, and the possibility of setting it free by breaking down the cyst by pressure. In *Trachelius* the development of the cyst, to the stage described, occupied, according to Cohn, only ten minutes. Where the process advances beyond this degree, the cyst commonly acquires a denser and firmer consistence; the animalcule can no longer deliver itself at once of its own accord from its prison, but undergoes a further change from its normal form, and requires those vivifying influences of external warmth, light, and moisture, such as spring-time brings with it, to arouse it from its torpid state, and to cause the reappearance of its hitherto obliterated organs.

Stein has very copious details of the whole process of encysting in various Ciliated Protozoa; but in none is that process more interesting to follow than in the *Vorticellina*. In members of this family the state of extreme contraction, induced by some external cause obnoxious to them, becomes fixed, and only the irregularly-curved space covered over by the completely-closed peristom indicates the complicated ciliary apparatus of the head; and even this decreases to a streak, and at length vanishes altogether. Whilst this goes forward, a membrane forms around the being which is now detached from its stem, and a globular or ovoid cyst, containing a nucleus and a contractile vesicle, is the representative of the once active and elaborately-organized *Vorticella*.

To what degree the encysting process may advance without depriving the animal of its ability to recover its freedom and original character, is well exemplified by Auerbach's observation on the cysts of *Oxytricha Pellionella* (XXIX. 21, 24) (*Zeitschr.* 1854, v. p. 430). This able microscopist found a number of globular cysts, with two coats, enclosing a homogeneous, finely-granular, brown substance, within which was a darker, rounded body (XXIX. 21), or at times two, and more rarely three such, seemingly derived from it, indicating the nucleus. The contents naturally filled the capsule; the addition, however, of a little muriatic acid caused them to shrink into a roundish body, somewhat more extended on one side, and traversed by a few deep folds or fissures (XXIX. 22). Such were the bodies met with during the continuance of winter; but when early spring arrived, these began to exhibit signs of vital activity within.

The first change remarked was the appearance of a vesicle, which by degrees acquired increased contractility; then the body retracted itself from the cyst-wall and commenced to revolve in a vacillating manner, whilst the outer granular lamina of the cyst broke away. Cilia now could be seen distributed over the surface of the animal, and a close row of much stronger ones along a fold recalling the characteristics of *Stylonychia* or of *Oxytricha*, although the animal still wanted the general conformation of the body peculiar to either of these genera (XXIX. 23). All this time the darker nuclear body or bodies had retained their existence and position, whilst the contractile vesicle, on the other hand, grew smaller, apparently by the expulsion of part of its fluid contents to occupy the space left between the animal and its capsule by the contraction of the former. The enclosed body, when freed from the wall of the cyst, commenced moving, not in a regular rotation, but in a jerking manner, from side to side as it turned, until at length it ruptured the walls of its prison and made its escape. The animal thus set at large presented the characters of *Oxytricha* (XXIX. 24) distinctly enough to recognize it as belonging to the genus; and at the same time the numerous escaping germs and the rapid appearance of a multitude of *Oxytricha Pellionella* of all sizes confirmed this view of their nature. Nevertheless a slight difference existed between the newly-emerged individuals and mature specimens,—the former being more oval, and their contents less hyaline, more granular, and of a yellowish colour by transmitted light: still, specimens occurred of every intermediate shade.

This observation by Auerbach demonstrates to us how completely modified and actually lost the characters of an animalcule may be when it becomes encysted even temporarily, during what has been termed the winter-sleep; for, as that writer shows, the *Oxytricha*-cysts he discovered could not have been ova, or a mere transitional phase to a higher form of existence. Similar instances of cyst-evolution are recorded by other observers; but generally the whole history of the cyst is not given, but only that portion in which an actual animalcular form, in movement by means of cilia, has revealed itself; such is the instance of *Amphileptus Fasciola* mentioned by Cohn (*Zeitschr.* v. 1854, p. 434). Furthermore, variations in the internal appearance and perceptible contents of cysts vary in different species, just as do their walls; thus, for example, in *Oxytricha*-cysts the contractile vesicle had vanished and appeared *de novo* only when its vital activity was resumed,—while in other cases this sac or space never disappears, but is even more prominent than the nucleus before the action of reagents, which is true of most, or of all, *Vorticellina*.

The particulars recounted by Mr. Brightwell respecting *Zoothamnium Arbuscula* ('Fauna Infusoria of Norfolk,' 1848), which he thought indicative of a mode of development by alternate generation, appear to us to represent probably the act of encysting, or that degree of it assumed by gemmæ prior to detachment from their parent stem, and retained by them until they have taken up a fixed position and proceed to develop a peduncle (see section on Fission and Gemmation). We extract Mr. Brightwell's account, so that our readers may form their own opinion of the nature of the phenomena detailed:—

"Sept. 16th, 1846. Early in the morning of this day, we observed one of the *Zoothamnium arbuscula*, a large old specimen, which had lost all its small bell-shaped animals, but had several medlar-shaped buds or ova remaining upon it. It was seen to detach from its stalks nearly all these ova, which went off as free animals. One of them soon after settled at the side of the water-trough, and after agitating its anterior cilia it suddenly, and with a kind of violent effort, opened into a cup-shaped form, and darted about with great rapidity, occasionally settling, and darting off again.

"At nine in the morning, one of these buds, or ova, was observed fixed to the glass by a sheathed pedicle; a ciliary motion became perceptible at the top of the bulb; and at ten it had divided longitudinally into two buds, each supported by a short stalk. The ciliary motion continued in the centre of each of these two buds, which by degrees expanded longitudinally, and at twelve had become four buds. By four in the afternoon, these four buds had divided in like manner and increased to nine, with an elongated foot-stalk, and interior contractile muscle.

"During the development of another specimen, the stalk appeared to have transverse ribs or joints, and, whilst a drawing was making, gradually bent downwards, and all the buds severally detached themselves from it, and went off as free animals, leaving only the bent stalk. In this interesting process we see something analogous to what Steenstrup describes as 'a mode of development by means of nurses or intermediate generations.'

"This mode is described as that in which an animal produces a progeny permanently dissimilar to itself, but which progeny produces *a new generation*, in itself or its offspring, returning to the form of the parent animal. It will be seen that this development differs from that of metamorphosis, in the circumstance of the intermediate animal (the nurse) being itself a permanent and producing form.

"To show this to be the case with *Zoothamnium*, it would be necessary to prove that the medlar-shaped animals were a permanent form, producing a race which, in themselves or in what they produced, returned to the form of the parent animal.

"We have not been able to carry the development of these buds or ova further than Pl. 12. f. 67, 68, 69, and wood cut" (see Part II.). "And it is remarkable that in all these the buds have produced, not the little bell-shaped animalcules like the parent animal, but other buds like themselves. May it not be the case, that these medlar-shaped bodies are propagated at the close of the year, and that, when the plant to which the *Zoothamnia* bearing these bodies are attached dies away, they remain in the mud, protected from the cold of the winter, and in the spring burst forth, and settle upon the new-growing plants, and produce animals of the parent-form. They would thus form an intermediate nursing race answering to Steenstrup's description."

Prof. Cienkowsky has witnessed (*Zeitschr.* 1855, vi. p. 301) cyst-construction in *Nassula viridis* (Duj.) (XXVIII. 65—71), *Stylonychia pustulata* (XXVIII. 74—76), *S. lanceolata*, in various *Vorticellæ*, in *Bursaria truncatella*, *B. lateritia*, *Podophrya fixa*, *Loxodes Cucullulus* (Duj.), *Leucophrys Spathula*, *Amphileptus margaritifer*, *Holophrya brunnea*, and less completely in *Amphileptus Anas*, *Stylonychia Mytilus*, *Paramecium chrysalis*, *Spirostomum ambiguum*, *Stentor polymorphus*, *St. Mülleri*, *Paramecium Aurelia*, and *Loxodes Bursaria*.

In *Loxodes Cucullulus* (Duj.) and *Stylonychia pustulata* he saw the discharge of the whole of the contents of the cyst in the form of encysted Infusoria. The embryo born from the cysts of *Stylonychia pustulata* resembles closely the *Trichoda Lynceus*, and can multiply itself by self-fission just in the same manner as mature and independent beings.

In cyst-development, he observes, the whole of the contents are, as Jules Haime stated, not metamorphosed into the resultant embryo, but one or more portions escape in the form of globules, apparently ciliated, and move off with a rotating motion.

Reproduction of the Ciliated Protozoa:—Fission, modes of; Gemmation; internal Ova producing Germs or Embryos; Impregnation; Production of new Beings with and without Metamorphosis; Transformation into Acinetæ, and Development of Embryos.—Until lately, naturalists in general did not acknowledge other methods of reproduction than by fission, or, as some would call it, fissation, and by gemmation or budding, which, from not being true generative acts, have been called 'vegetative' modes of propagation or multiplication. Recently, however, the Ciliata have had attributed to them true generative processes, resulting in the development of embryos either with or without intercurrent metamorphoses.

The simpler processes of fission and gemmation are, in Stein's opinion, modes of propagation peculiar to immature beings, and are replaced in mature animalcules by the agency of germs or embryos.

Fission.—This duplicative subdivision may be longitudinal, transverse, or oblique; and whilst some species divide in only one direction, others are capable of so doing in two, for instance, in the longitudinal and transverse, but not simultaneously. Among the *Vorticellina* longitudinal fission alone occurs; *Paramecium* (XXIX. 27), *Chilodon*, and others divide both longitudinally and transversely; *Lagenophrys* obliquely only. Fission has not been witnessed in *Spirochona* nor in *Trichodina*, nor in *Colpoda* when in a free state and not encysted.

Ehrenberg came to the conclusion that multiplication by spontaneous division is the character which separates animals from plants. It is true (he argued) that gemmation in plants, especially in very simple cells, is at times very similar to the division in animals; but this relates to the form, not the formation. A vegetable cell, apparently capable of self-division, produces one, or contemporaneously many exterior buds (*gemmæ*), without any change in its interior. An animal which is capable of division, first doubles the inner organs, and subsequently decreases exteriorly in size. Self-division proceeds from the interior towards the exterior, from the centre to the periphery; gemmation, which also occurs in animals, proceeds from the exterior towards the interior, and forms first a wart, which then gradually becomes organized.

This supposed distinction between fission in vegetable cells and that in simple animals like Infusoria is set aside by modern researches, which show that, when a plant-cell is about to divide, the mucilaginous layer of the wall (*i. e.* the primordial utricle) manifests a constriction, which presently involves the wall itself, and, gradually deepening, at length cuts the cell into two. The observations on this subject in the chapters on Desmidieæ and Diatomeæ will more completely elucidate it.

Considered with respect to the condition of the animalcule, fission occurs in the active and unchanged state, as in *Paramecium*; or in a contracted state, as in *Vorticellina*; or only when encysted, as in the case of *Colpoda*. Hence it follows, that it presents several slight modifications in its course. One general fact is, that whilst fission proceeds, the rotation of the contents of the animalcule is at a stand-still. In its simplest variety, the dividing being first presents a constriction at each pole or side of the body, which gradually extends until it completely cuts it into two equal or unequal parts. Simultaneously with the first indication of an act of fission, and in some cases before a sign of it is to be detected in the periphery of the animal, it has been generally taught that the nucleus, after elongating and usually disposing itself across the direction of the line of scission, takes the initiative in the act, by commencing a fission of its own substance (XXIX. 27), which subsequently proceeds step by step with that of the entire body, until complete. This statement is, according to Lachmann (*A. N. H.* 1857, xix. p. 230), a mistake when made respecting the Protozoa generally; for in some cases the division of the nucleus is consecutive to that of the body, and "in others, again, the actual fissation of the nucleus does not lead to that of the body, but embryos are developed in it;" on the other hand, "fissation is generally commenced rather by a new formation of contractile vesicles."

In some species where fission proceeds on its simple type, food may continue to be received for a short period by the dividing animal. The small share the abdominal contents within the cortical lamina have in the vital processes, is shown by Lachmann's observation of a *Stylonychia*, "which, although a considerable part of its chyme had been sucked out of it by an *Acineta*, still underwent division, so that one of the gemmules of division swam away from it briskly, and only the other half of the old animal was destroyed."

The direction of the line of section is perhaps, when longitudinal, usually from before backwards, the constriction appearing first and advancing more rapidly at the head; but the contrary, according to Stein, prevails in *Chilodon Cucullulus*, where the constriction makes its way solely from the posterior pole.

When fission is transverse or oblique it necessarily involves the reproduction, in the posterior half, of the organs existing in the anterior, viz. the ciliary apparatus of the head, the oral aperture, the tube prolonged from it, and the contractile vesicle. So far, therefore, it approaches nearer the act of gemmation than does longitudinal fission, wherein segments of the already existing organs are separated for the purposes of the new individual, and are not actually reproduced or created anew. "In those Infusoria," says Lachmann (*A. N. H. loc. cit.*), "in which a peculiar series of stronger cilia leads to the mouth (such as *Oxytrichinæ* and *Euploteæ*), the furrow in which this series of cilia is situated is seen, subsequently to or simultaneously with the division of the contractile vesicle, to become produced backwards over the mouth; in this prolongation cilia are produced, and its posterior extremity becomes deepened into a mouth and œsophagus, which then opens towards the alimentary cavity of the animal; then, simultaneously with the external constriction of the body, the new furrow is separated from the old one. (In *Stentor* the new frontal series of cilia first makes its appearance on the old animal as a lateral straight series—the *crista lateralis* of Ehrenberg). In animals which also possess peculiar processes of the body as organs of motion (hooks, styles, &c.), the fissation usually takes place in such a manner, that each of the newly-formed animals acquires a portion of these from the old animal, whilst the other part is of new formation."

The manner in which self-division proceeds in Protozoa with a firm, and seemingly almost brittle integument, is exemplified in *Coleps* (XXIV. 284, 285). Along the line of section a new secretion of chitinous substance takes place, soft in consistence and transparent, which by its increasing width separates the two portions of the original lorica; in this interposed new tissue a constriction presently manifests itself, and advancing in depth, the two segments are finally sundered. It thus comes to pass that each product of fission is one half covered with a dense shield, and the other half with a soft, yielding integument. After a while, more molecules make their appearance in the latter, which gradually assumes a firmness equal to that of the old lorica.

The *Vorticellina*, including the *Ophrydina*, do not divide until they have assumed a sort of semiquiescent condition, by the complete withdrawal of their ciliary apparatus and the contraction of the body generally into a more or less rounded or oval shape,—in short, until they have advanced one step towards encysting themselves.

Ehrenberg portrayed their fission as a simple constriction advancing from before backwards to separation of the body; but Stein pointed out the actual antecedents of the process. According to the latter writer, the head-portion and its appendages withdraw; the rotary organ is absorbed, and also the œsophagus; at the same time the contractile space vanishes; the body expands in width, the nucleus outstretches itself across it, a constriction appears on its anterior border, and, extending constantly in depth, at length effects its complete division. When the section has reached the third of the body, a conical space displays itself towards the anterior portion of each half (XXVII. 3), lined by a special membrane, covered by cilia on its posterior side or base, which are seen to vibrate within the cavity. This formation is the rudiment of the future rotary organ. The apex of the conical hollow is prolonged by a canal which eventually opens on the surface, and thus establishes a continuity between the lining membrane and the external integument. At the same time the internal angle at the base of the cone is produced inwards so as to form the alimentary tube. When these changes are accomplished, the body is half cut through, and the appearance is rather that of two individual animalcules united posteriorly, having their ciliary apparatus retracted, and the peristom contracted in a splinter-like manner over it. Lastly, the advancing act of scission divides the nucleus; and the whole body becomes resolved into two individuals seated upon the same stalk. From this account it follows, that, of the original organs of the animalcule, the nucleus is the only one divided between the two resultant beings by the process of fission; all the rest are formed anew out of the homogeneous substance of the body, viz. the peristom, the rotary organ, the alimentary tube, and the contractile vesicle.

This absorption and renewal of parts during fissation is denied by Lachmann, who affirms that the movement of the cilia upon the ciliary apparatus, and in the vestibulum and œsophagus, which are closed up by the peristom, may be observed during the whole process. We have no means of deciding which of these two statements is correct: yet we rather incline to Stein's account; for when we admit that in fission there is a separation of all the organs and appendages of the body into two portions, one to each resultant being, an act of structural development becomes necessary to reproduce the remaining portion, so as to perfect each new animal and to assimilate it in characters to the parent. This being the case, the method of development stated by Stein is more consonant with our views of histogeny than that of Lachmann.

The oblique fission of *Lagenophrys vaginicola* (XXX. 32, 35, 36) presents several peculiarities. The line of section commences below the peristom on one side, and proceeds diagonally across to the opposite, and thus gives rise to an anterior lateral segment retaining all the special organs, and a posterior lateral possessing nothing save its half of the elongated divided nucleus. During the process, the anterior half continues in the enjoyment of all its functions and activity (XXX. 32), whirls its ciliary organ, and takes in food by the mouth: the food, however, does not reach to the segment behind; and whatever alimentary particles might be present in this vanish, and its whole contained substance becomes homogeneous and granular, the half of the curved band-like nucleus extending into it. When the line of section is fully formed, Stein remarks that the posterior lateral segment rather resembles a gemma than the result of self-division, and proves how closely united are the two processes of gemmation and of fission.

When the scission is nearly complete, a contractile space appears, and, either before or behind this, a curved elongated cavity, ciliated on one side and produced upwards as a tube from one angle, is formed (XXX. 35), out of which the rotary organ and peristom are developed. As there is no room for movement, the new being lies motionless close against the old one: however, its contractile space acts energetically; and the alimentary tube, filled with fluid, moves upwards and downwards, and from side to side within it. At length a row of cilia appear around the circumference of the body; and now two beings occupy one case, the anterior adhering by its peristom to the narrow orifice of the sheath, whilst the posterior lies immediately behind it, fixed from want of space, and unable to free itself (XXX. 36). The question that now presents itself is, how is the newly-formed animal to escape its prison and to exercise its vital endowments? This, Stein has been able to solve by observation of another species of *Lagenophrys*, viz. *L. Ampulla.* The upper segment ceases to put forth its ciliary organs and to take in food, and shortly contracts itself and detaches its hold from the opening of the external sheath, developing simultaneously a row of cilia around its margin (XXX. 35). It also not unfrequently happens that the body is divided from the peristom, leaving this portion adherent in its natural position to the orifice of the sheath, and possessed of such remarkable vitality, that it continues to contract and dilate, and to implicate the orifice of the sheath itself in its movements (XXX. 35). When the peristom, with a portion of contractile sarcode (35 *b*) enclosing at times a contractile space within it, thus plugs the only outlet from the cyst, the two products of fission cannot gain their liberty, and only enjoy the limited degree of locomotion allowed within their narrow prison-house. But where, as is more common, the orifice is opened, they sooner or later make their way out, experiencing, nevertheless, some difficulty in passing through the narrow outlet.

A curious circumstance pertains to these fission-products of *Lagenophrys*, and indeed to those of all the *Ophrydina* and *Vorticellina*, viz. they are not precisely like the parent. Thus, the young of *Lagenophrys*, produced as above described, exhibit the rotary organ and peristom in a contracted condition, whilst a row of cilia surrounds the body in a ring-like groove on the abdominal surface, and serves the purpose of a locomotive organ (XXX. 35, 36). On the ventral aspect, adds Stein, the figure of the animalcule recalls that of *Stylonychia*, between which and the normal form of *Vorticellina* it may be considered a transitional type.

Turning now to the other members of the *Vorticellina* and *Ophrydina*, we see that the history of the fission-products differs according to their habits and structural peculiarities. In the branching forms many of the newly-formed beings proceed each to secrete from its base a pedicle, and so continue the dichotomy of the little arborescent colony they belong to. Others, on the contrary, detach themselves from the parent-stem and enter on a free and independent existence. In this case one of the two segments consequent on self-division, in order to enter on its new mode of life, undergoes certain modifications in structure, viz. it continues in a completely contracted state, and a furrow appears about the posterior third of the body, within which a ciliary circlet develops as the locomotive organ of the animal (XXVII. 11). This occurrence is general among *Vorticellæ* and *Ophrydina*; for among the former the pedicle never ramifies, and in the latter one fission-product must quit the capsule, which serves as the nidus of only one being at a time.

The after-history of these locomotive segments is widely different in different specimens. Some, after swimming about for a time, come to a state of rest, affix themselves by their posterior extremity, and produce, according to their natural habit, either a stalk or a sheath, and resume all the characteristics of the parent-stock. Others, again, become quiescent, but instead of secreting a pedicle or sheath, proceed to encyst themselves, either for their own preservation or preparatory to the fulfilment of an act of reproduction. Indeed, the process of encysting may overtake the animals whilst still seated on their stalk or within their case, and thus anticipate the formation of the posterior ciliary wreath.

Lastly, in a few genera, fission seems only, or at least mostly, to occur after the animalcules are encysted. Stein represents this to be the case generally in *Colpoda Cucullulus*, which he never found in process of fission (XXIX. 38–47). Indeed, Ehrenberg himself never saw self-division of this animalcule, although he has, on the authority and ambiguous observations of some of the old observers, described its occurrence. According to Stein's researches, encysting would not appear absolutely necessary; for he witnessed self-division in some specimens only contracted in a spherical form: however, in others, the more numerous, a cyst was thrown around the body before that process ensued. According to the general plan, the Ciliated Protozoa divide into two; yet there are some—and *Colpoda* is one of such—in which the act of fission is repeated, and 4, 8, and even 16 segments and upwards result. The products of fission have a certain latitude of motion within their cysts, and ultimately escape by rupture. Another peculiarity about *Colpoda* is, that the segments resulting from fission secrete individually a capsule around themselves, and thus we have encysted beings enclosed within a general cyst. Lastly, each young cyst has its own nucleus and contractile vesicle (XXIX. 43).

The fission of the animal when encysted appears to be the rule in *Glaucoma*; for example, in *G. scintillans*; and Stein surmises that it is this occurrence which Cohn witnessed in *Chilodon uncinatus*, and thought to be two animalcules enclosed within a common cyst, as happens with *Gregarinæ*.

The importance of fission as a means of multiplying individuals among the Ciliata admits of numerous striking illustrations. We may quote one given by Ehrenberg, by no means an extraordinary instance. He made out that a single individual of *Stylonychia Mytilus* lived nine days: during the first 24 hours it divided into 3; and during the next space of 24 hours each of these three had subdivided into two beings; so that by self-division alone this animalcule can multiply itself three or fourfold in four and twenty hours, and in the space of ten days be represented by a million derived beings or offshoots. Another instance may be adduced from the same distinguished micrographer. On the 14th of November, he divided a *Paramecium Aurelia*, $\frac{1}{12}$th of a line in length, into four parts, each of which he placed in a separate glass. On the 17th, the glasses numbered 1 and 4 each contained an isolated *Paramecium* swimming actively about. The pieces in Nos. 3 and 2 had disappeared. On the 18th, there was no change. On the 19th, each animalcule presented a constriction across the middle of the body. On the 20th, No. 1 had propagated 5 individuals by transverse fission, and No. 4 eight such. On the 21st, no change had taken place. On the 22nd, No. 1 contained 6, and No. 4, 18 specimens. On the 23rd, the beings produced were too numerous to be counted. From these notes Ehrenberg calculated, if this process continued in activity for a month, 268 millions might be produced. Apart, however, from these, which we may term speculative considerations, we have in *Ophrydium* the clearest and most direct evidence of the extent to which fission is carried out. On the completion of self-division in this animal, the products remain together, connected by a common gelatinous mass at their base exerted by themselves. By the repetition of the process again and again, through a long series, the *Ophrydia* accumulate in large greenish masses, or polyparies, at times of the size of the fist or even of the head of a man. Now, by comparing the size of the individual *Ophrydia* (about $\frac{1}{120}$th of an inch in length) with that of the masses they form, "some estimate," says Dr. Carpenter (*The Microscope*, p. 487), "may be formed of the number included in the latter; for a cubic inch would contain nearly *eight millions* of them, if they were closely packed; and many times that number must exist in the larger masses, even making allowance for the fact that the bodies of the animalcules are separated from each other by their gelatinous cushion, and that the masses have their central portions occupied only by water. Hence we have in such clusters a distinct proof of the extraordinary extent to which multiplication by duplicative subdivision may proceed without the interposition of any other process. These animalcules, however, free themselves at times from their gelatinous bed, and have been observed to undergo an 'encysting process' corresponding with that of the *Vorticellina*. It is much to be desired that microscopic observers should devote themselves systematically to the continuous study of even the commonest and best-known forms of these animalcules, since there is *not a single one* whose entire life-history, from one generative act to another, is known to us; and since it cannot be even guessed at, without such knowledge, what, among the many dissimilar forms that have been described by Prof. Ehrenberg and others, are to be accounted as truly distinct species, and what are mere phases in the existence of others that are perhaps very dissimilar to them in aspect, it is obvious that no credit is really to be gained by the discovery of any number of apparently new species, which shall be at all comparable with that to be acquired by the complete and satisfactory elucidation of the life-history of any one."

Gemmation (illustrated by XXVII. 1–4; XXX. 17, 27, 29, 31, 33, 34).—This is the next process of multiplication to be considered. It has much analogy with fission, but is not nearly so widely diffused, being restricted apparently to the families *Vorticellina* and *Ophrydina*, that is, to attached species of Ciliata; yet even among these it would seem not to be general: for Stein has failed to observe it in the genus *Opercularia*. In it a prominence forms upon the surface, mostly near the posterior extremity, and of the same granular homogeneous substance as the rest of the animal: a line of constriction soon displays itself, and gradually deepens, whilst the budding process increases in size and developes internal organs and external appendages, until, being sufficiently perfected for an isolated existence, it severs itself from the parent stock. The gemmæ or buds thus produced are much smaller than the parent, and, even when they have acquired their largest dimensions before separation, are less than the new beings originating from self-division. In every instance of fission the nucleus becomes divided between the two segments; and some authors, as we have seen, hold the opinion that these share between them a portion of other pre-existent organs of the dividing animal; on the other hand, in gemmation the bud is a mere offshoot of the general substance, containing no portion of any pre-existing organ—not even, so far as can be seen, of the nucleus; and consequently all the specially-organized parts are developed in it *de novo*. If the doctrine of internal germs be admitted, then it may be imagined that each gemma originates from one of these, which takes on this external direction of development.

On the completion of the gemma, we find that it resembles (except in *Spirochona* and *Lagenophrys*) a completely-contracted specimen of the parent animalcule, and possesses, in lieu of the usual ciliated whorl on the head, a posterior ciliary wreath, whereby, when detached, it swims freely away, with the posterior extremity, however, in advance. It resembles, therefore, in all respects the product of fission when separated from its fellow, and, like it, may either presently attach itself, losing its posterior circlet of cilia, and acquire all the characters of its parent—as well as, in process of time, its dimensions,—or advance to a completely encysted state, preparatory to a process of development, or simply for the object of preservation from untoward external conditions. The act of gemmation goes on alike in small and in large specimens. Stein notes its occurrence in *Vorticellæ* of only $\frac{1}{84}'''$ in length.

A few illustrations may render the above account of gemmation more clear.

Speaking of this process in *Vorticellæ*, Stein (*op. cit.* p. 28) says, the interior of the knob-like process is quite homogeneous at first (XXVII. 1); but when it has attained a hemispherical shape, a crescentic cavity forms at its anterior part, from which the peristom, rotary organ, and alimentary tube are eventually developed (XXX. 17, 27), just as happens in the result of fission. Whilst this proceeds, the swelling acquires an oval or globose figure, and the width of its attached base dwindles to a constricted neck or isthmus. The addition of acetic acid proves that no portion of the nucleus extends into it, but that this organ retains its normal curved reniform figure. Stein here adds the remark, that no sharp line of distinction exists between self-fission and gemmation—that the latter may be looked upon as an act of unequal division, in which the whole organization has to be created, and not, as in fission, simply perpetuated; or fission may be described as a variety of gemmation, one segment being regarded as a bud; at least this view holds good in the case of transverse fission. Longitudinal fission consists in the formation of two gemmæ, which subsequently involve the entire being. So also in one sense gemmation does not always end in the production of a single bud; for *Vorticellæ* with two are common, and occasionally with three, one of which is ready for detachment, whilst the other or others are very incomplete.

In *Spirochona* (XXX. 17, 27), which does not multiply by fission, gemmation is very frequent; and often two buds are produced, one immediately behind the other, the hindmost being first in development. Where two exist, the first-formed usually appears on the side of the body at its widest part; and the second forms subsequently in front of it, nearer the neck. Relatively to the size of the parent, the bud is usually of greater dimensions than in *Vorticella*, and may, by thrusting aside the head of the *Spirochona*, place itself in the longitudinal axis of the body. When the gemma commences to contract its base and to acquire the form of an independent being, an opaque, sharply-defined, homogeneous speck makes its appearance about its middle, or, rather, in front of it, which, by further development, becomes the nucleus (XXX. 17), whilst a shallow groove displays itself at its anterior truncate end, and somewhat later is transformed into a curved and rather angular ciliated fissure extending some way down one side of the body.

In this so-formed gemma of *Spirochona* there is, therefore, a wide departure from the rule observed in any of the *Vorticellina* and *Ophrydina*. No posterior ciliary wreath is formed; and the anterior ciliary apparatus, together with the head itself, is at first developed in a temporary and rudimentary manner. After moving about for some time by means of the ciliary antero-lateral channel, the free gemma fixes itself by its posterior extremity, by an adhesive substance, or occasionally by a short stem; and then the opposite sides of the ciliated furrow approximate, and coalesce behind, whilst in front one edge rises above the other (XXX. 19), and soon forms a spirally-convoluted membrane, which becomes clothed with cilia replacing those of the old furrow, which are absorbed and disappear (XXX. 20). This growth into perfect *Spirochonæ* does not happen with all gemmæ; for some assume a quiescent condition, become encysted, and, if Stein be right, are ultimately converted into very peculiar Acinetiform beings—the *Dendrocometes paradoxus* (XXX. 23). Before encysting, the cilia cease to play, and disappear; and very soon the furrow itself closes up. When enclosed within the transparent but firm capsule, nothing but a finely-granular homogeneous substance appears, containing the peculiar nucleus, which, however, requires the action of acetic acid to display it (XXX. 21).

The process of gemmation presents several peculiarities in the genus *Lagenophrys*, due mostly to the peculiar connexion between the enclosed animalcule and its sheath. The rule seems to be that two or four gemmæ are produced within the sheath at the same time (XXX. 29, 34); but since Stein had never encountered four, and very rarely three, gemmæ upon any animalcule, the idea crossed his mind that these small buds of *Lagenophrys* might perhaps be embryos developed within the interior, and subsequently discharged. Another explanation was possible, viz. that they were animalcules which had found their way into the sheath, and were quite foreign to it. However, both these hypotheses are set aside by the history of development and by the characters of the beings produced. The process consists in the enlargement of the posterior extremity (XXX. 33), or of a part of the side of the *Lagenophrys*, and the progressive detachment of the enlargement as a segment or bud, and simultaneously the production of a band-like nucleus and contractile vesicle within it. This stage being so far complete, the gemma does not proceed to develope into the form of the parent animal, but self-fission takes place, and two similar ovoid bodies, each with its contractile vesicle, is the result (XXX. 29). When the constriction of the single gemma announces approaching fission, a circlet of cilia appears on each side of it (XXX. 34); and on the completion of the process, each segment has a conical head surrounded with a wreath of cilia.

From this mode of production in pairs, the number of gemmæ within the sheath of *Lagenophrys* should always be two or a multiple of two; hence, when three are seen, it is to be presumed that one has previously made its escape. From the peculiar way in which the body of the *Lagenophrys* is suspended by its attached peristom to the orifice of the sheath, it is clearly impossible that anything can directly either make its entrance into or its escape from the animal, without rupture, of which we have no indication. The way in which this impediment is surmounted is, on Stein's authority, by the sudden contraction of the body of the *Lagenophrys* rupturing the adhesion of the peristom to the orifice of the sheath, and by its subsequent retraction within it (XXX. 31). In this manner a free exit is afforded to *any* contained gemmæ; and after a certain time allowed for their passage, the anterior part of the body again enlarges itself, and reassumes its adhesion to the sheath. After their exit, Stein has no observations to show what becomes of them; but his idea seems to be that they do not produce a sheath until nearly arrived at maturity, since they are so much smaller than the least of the sheathed examples to be met with.

If this account be correct, the gemmation of *Lagenophrys* is actually a compound process of budding and fission, whilst the resultant beings differ widely from those of other *Vorticellina* in all details, and are so very aberrant in form from the parent, that they require to undergo a metamorphosis before they gain it.

Development from Ova. Internal Germs and Embryos.—Although the reproduction of the Ciliated Protozoa is so largely provided for by the two processes of fission and gemmation as just described, it is even more marvellously so by their possession of true generative functions—a fact clearly established by the latest observers, although denied by Siebold, Kölliker, and others some years since, when the unicellular hypothesis of Protozoic life militated against the notion of the existence of internal ova or germs. Even now, indeed, when we look to the researches disclosing to us the development and discharge of germs and of living embryos, we find diverse and contradictory statements concerning both the antecedent or preparatory acts, and the final results. We cannot attempt to reconcile these discrepancies, but will record the principal opinions of naturalists and the observations on which they are based.

In a previous page we have stated the views of Carter and Perty, relative to the existence of ova or germs in the interior of Ciliated Protozoa, and have rejected them as unsatisfactory. Further, when we come to inquire the process of development of the presumed ovules, their mode of exclusion, and other particulars necessary to complete their history and even their identification, we find that those naturalists have no direct observations to adduce, but can appeal only to analogy and to some casual and unconfirmed observations of others. For instance, Mr. Carter, when treating of the development of ovules, appeals to the process in *Spongilla* and *Euglypha*, and endeavours to make out that, with some modifications, the ovules of *Euglenæ*, and probably those of all the Rhizopods and *Astasiæ*, have a similar mode of generation.

Perty, likewise, unable to advance any direct proof of the existence of ovules and of their discharge, appeals to Eckhard's observations on *Stentor cæruleus*, which Oscar Schmidt repeated and generally confirmed. In the recorded observation of Eckhard (*A. N. H.* xviii. 1846), three or four globules, in different stages of development occurred in the interior of the *Stentor* in a row (XXIX. 8–13):—"In the first stage, the contents of the globules, consisting of minute granules, exist most imperfectly developed: but few granules at present occur, and the globule, when it lies in the body, is not very distinct, on account of the granular parenchyma of the latter. In the second stage of development (fig. 9) the granules appear more numerous, the contents are therefore more concentrated, and the globules can then be very distinctly observed in the body. Fig. 11 shows the third stage; granules commence arranging themselves in a row..... Or, as sometimes happens, they appear grouped in the same manner at two spots. The granules thus arranged and closely pressed together, blend into a glandular but clear organ (fig. 12), in which the granular structure cannot be any longer detected; frequently it is also divided in two parts. Lastly, in the situation of the transparent glandular organ a row of cilia appears, evidently the mouth (fig. 13). Whether this organ is formed immediately from the former, I have not been able to ascertain with certainty; yet that it is so, is extremely probable, since on the one hand the row of cilia occurs in the situation of the bright gland, whilst, on the other hand, in all the germs which exhibit this, the former organ is absent. Simultaneously with the development of the mouth there appear one or two clear vesicles (fig. 13). On the 18th of May I observed in the interior of *St. cæruleus* a germ as in fig. 12; I saw the cilia very distinctly in motion; the vesicles were, however, still absent, and they did not escape on this occasion. On the 21st, I saw the perfect form (fig. 13), which issued out, whilst the parent animal swam away. I now attentively observed the young one to follow up its further changes, perhaps the bursting of the carapace; but I was obliged to leave off watching it in half an hour, as I could not vouch for the accuracy of further observation on account of the strain upon my eyes. On the 4th of June I saw a germ escape, as in fig. 13: it differed from that observed on the 21st of May; for, being at first round, it at once exhibited an incurvation at its lower extremity—an appearance frequently observed in young Stentors, sometimes in old ones, when they contract from the elongated form to one more or less rounded. I have subsequently once seen the escape of a similar germ; and it appears to me that the true point of maturity is that at which vesicles begin to be visible. In *Stentor polymorphus* I have observed two such globules, but I have not succeeded in seeing any perfectly formed escape. In autumn I have often sought for the recurrence of this phenomenon, but have never been able to observe it so perfectly as in the spring, although similar globules are not rare in the later parts of the year."

From the perusal of this account, the thought arises, whether, instead of proving the existence and progressive development of internal ovules or germs in the sense Perty adopts, it is not another illustration of embryo-development by a sort of gemmation or breaking up of the nucleus, such as the researches of Cohn, Stein, Lachmann and others have made known to us, and concerning which we have now to speak (*see* Balbiani's researches, p. 329).

The development of the nucleus into embryos takes place under different circumstances and in a varied manner in different genera of Ciliated Protozoa. It may occur either without the previous encysting of the animalcule, or after this process is completed. Again, in the latter condition, and without ulterior change or metamorphosis, either a few active embryos, or some encysted germs, may be the result, or the whole nucleus may resolve itself into a brood of monadiform beings, or, lastly, according to the views of Stein, the encysted animal may be metamorphosed into an Acinetiform being, out of which embryos are developed diverging in character more or less completely from the original ciliated Protozoon, to which, however, they eventually recur. The development of embryos without the previous encysting of the animalcule has been followed out by Focke, Cohn, and Stein in *Nassula* and in *Paramecium* (*Loxodes*, Cohn) *Bursaria* (XXVIII. 10–14, XXIX. 28 to 34). A portion of the nucleus is separated by fission or by an act of gemmation, and constitutes a more or less orbicular body, in which a nucleus (XXIX. 34), and then a contractile vesicle, shortly declare themselves (XXIX. 29). Focke surmised that the so-called nucleolus originated this germ, which then found, as it were, a lodgment and nutrition in the nucleus as in a uterus (*see* Balbiani, p. 329); but Stein affirms that this body has nothing to do with the origin of the germ, and is frequently to be seen separated and removed to some distance from the nucleus (XXIX. 29). In appearance the disk-like germ is finely granular, paler than the nucleus, and not surrounded, like the latter, with a special membrane. Cohn represents it as existing in a distinctly limited cavity, prolonged to the external surface as a tube or oviduct, and terminated by a two-lipped orifice, through which the embryo makes its exit (XXVIII. 11, 12). According to Stein, however, no such duct and external orifice have an existence, except temporarily, during the passage of the germ, or germs when two or more follow in succession. This assertion of Stein is supported by Cohn's own observation, that the point of extrusion varied in different individuals in its position, being at one time at the middle, at another above it, at a third below it, and, as the rule, on the left side, although as an exception on the right side or even towards the anterior margin. The act of birth occupies about twenty minutes; and when the embryo is about to escape, it exhibits a vibration on its surface, which causes a motion in the surrounding water and hastens its detachment. This motion, after continuing a short time, ceases, and the little being attaches itself to the exterior of the parent (XXIX. 30). The chasm produced in the parent during the extrusion soon closes up, and leaves no trace, except, it may be, a slight hollow in the surface. The embryo has an elongated fissure, is rounded at each end (XXIX. 30), and frequently rather contracted at its middle; internally it is finely granular and colourless—not greenish, as Focke asserted—and contains, besides a darker nucleus, one or two contractile spaces (XXVIII. 14). Cohn could discover no mouth; but Stein displays in his figure an oblique fold or groove (XXIX. 30), which may possibly represent the oblique funnel-like vestibule of the mature *Paramecium*. The vibratile movement visible about the surface indicates ciliary action; and if the embryo be killed with iodine, the presence of long cilia is demonstrated. Still the most peculiar feature in the new-born animalcule is the possession of several soft tentacular processes at each end, surrounded by small knobs, recalling in figure the knobbed tentacles of some *Acinetina* (XXVIII. 14, XXIX. 30); by means of these the embryo secures its hold to its parent. Such processes are not present in all specimens, and are therefore non-essential; or it may be they have disappeared by withdrawal into the general substance of the body.

The embryo once freed from its parent, commences an independent existence, moving freely about in the water—much more similar in figure and structure, however, to some of Ehrenberg's *Cyclidina* or to Dujardin's *Enchélyens* than to *Paramecium*. Cohn notes its affinity with the *Cyclidium margaritaceum*, or to the *Pantotrichum Enchelys* (Ehr.), and also with several species of Dujardin's genus *Enchelys* (*Cyclidium* Ehr.).

Cohn adds that, in his opinion, several embryos are developed simultaneously, and that, where only one or two are found, others have already escaped. In some instances he has noticed as many as six or eight in process of development, and, it would seem, in almost precisely the same stage, although their birth is successive. Further, besides these normal embryos, he has frequently witnessed the escape of others having a globular figure, clothed with cilia and furnished with tentacular processes and a contractile vesicle.

During the act of birth, the pulsations of the contractile space of the parent are uninterrupted, and the rotation of the contents is arrested until every germ has escaped. Another curious fact is, that the birth of embryos may proceed as usual even whilst the act of fission is taking place in the parent animal.

The further history of the free embryo is not known; yet, in all probability, it is ultimately transformed into a perfect *Paramecium*,—an event which, from its figure and structure, ensues readily and perhaps without more than one intermediate phase.

Judging from the above details, it is probable, as before remarked, that the development of embryos in *Stentor cæruleus* (XXIX. 8) recorded by Eckhard (*suprà*, p. 354) was a precisely similar phenomenon to that just described in *Paramecium*; and it is clear that the like obtains in *Stentor polymorphus*, in an *Opalina* or *Bursaria* noticed by Siebold (probably the *Bursaria Entozoon* Ehr., parasitic in a frog), in *Urostyla grandis*, as mentioned by Cohn, and in the animalcule which we conceived to be *Trichodina pediculus* (*A. N. H.* 1849, iii. p. 269).

Since this was written, the indefatigable labours of Cohn have added another instance of this endogenous mode of development, in *Nassula elegans* (*Zeitschr.* 1857, p. 143; XXVIII. 11–14). This animalcule possesses an elliptic nucleus, having its nucleolus lodged in a fossa near one end, and surrounded by a vesicle, just as in the *Paramecium Bursaria*. Among many specimens, Cohn found several having a large, elliptic, hollow space, evidently limited by a membranous wall. Where this space approached nearest the external surface of the animalcule, this was depressed in a cup-like form, and from its centre a canal or fissure (XXVIII. 11 *f*) penetrated the interior of the space, where were two, never more, large globules, $\frac{1}{100}'''$ in diameter (XXVIII. 11 *d*). After a longer or shorter delay, these globules escaped and appeared motionless, without colour, but granular, and having a central nucleus and an excentric contractile vesicle. As in the instance of the germs of *Paramecium Bursaria*, no cilia, but a few short, knobbed, radiating, tentacular-looking processes (XXVIII. 14), were visible on the surface. Lastly, Cohn noticed the formation of these germs in animalcules recently produced by self-fission, and which had attained only one-half their normal dimensions.

The development of an embryo within an encysted animalcule is illustrated in Stein's history of *Chilodon Cucullulus* (*op. cit.* p. 134). At a preceding page (p. 342) we have given an abstract of the mode of encysting of this animal, and have stated that the capsule remains gelatinous and soft. Inside the cyst, Stein discovered an actively-moving embryo contained within a special cavity (XXIX. 54–56), occupying precisely the spot where in other encysted *Chilodons* the nucleus is found, viz. in the diagonal line connecting the two opposite contractile spaces. The embryo had an oval or ovate compressed figure, with one side straight or gently curved, and the anterior extremity notched. Its entire surface was covered with longitudinal, widely-separated rows of unusually long cilia, in incessant motion, which turned it in a spiral or vermicular manner. Pressure on the cyst caused its expulsion (XXIX. 59), either alone or together with the substance of the parent-cyst, to which it always remained adherent. This embryo, Stein concludes, is derived from the nucleus. Many cysts may be met with in which the nucleus is replaced by a much larger body, having a different consistence, opaque and motionless, and possessing in all respects the outline of a germ. On pressing it out of its place, its surface is seen to be not quite naked, but to have short, stiff, and imperfectly-developed cilia at one end or entirely around its margin.

Since the embryo occupies the site of the nucleus, it might at first sight be supposed that the latter was wholly transformed into it; but analogy leads us to the contrary inference, that the nucleus, although obscured from view by the internal germ, is nevertheless present; and this conclusion is further supported by the fact, that a successive development of embryos goes on until the entire contents of the cyst are used up in their formation, an event that does not occur without the influence of a nucleus.

Stein declares the embryo (XXIX. 59) to be precisely similar to *Cyclidium Glaucoma*, both in figure and movements. Its size varies with that of the animalcule producing it; and individuals of all sizes may undergo the encysting process. The smallest cysts met with were $\frac{1}{93}'''$ in length, and their embryo not more than $\frac{1}{230}'''$; the largest $\frac{1}{35}'''$, and their embryo from $\frac{1}{108}'''$ to $\frac{1}{96}'''$ (XXIX. 56).

A remarkable circumstance happens in the case of some encysted *Chilodons*, even after they have given birth to one or more embryos,—viz. that they seem to emerge from their quiescent state and resume their active form. For instance, Stein met with cysts containing a freely-moving *Chilodon*, together with an active embryo, both which ultimately escaped by an aperture in their walls (XXIX. 58). This revivification of the ciliated *Chilodon* as above referred to, is urged by Stein as an argument to prove that the cilia are not lost or destroyed when encysting takes place, but probably merely closely compressed against the surface.

Another variety of development of germs within an encysted animalcule is seen in *Colpoda Cucullus* (XXIX. 35–47), which we have described under the head of "Fission," since the formation of the germs is the consequence of self-divison of the whole animal either into two or, as a rule, into four segments, which themselves become individually encysted, and present their own nucleus and contractile space. This plan of development explains the occurrence of very small encysted *Colpodæ*.

It was in this genus that Ehrenberg conceived he had made out very clearly the hermaphroditism and cyclical development of "Polygastrica."

A third way in which the encysting of an animalcule is made to serve the process of development is by the resolution of the nucleus into a multitude of minute segments, each eventually assuming an independent animal existence. This formation of what may be called *brood*-cysts, occurs, as shown by Stein's later researches, in *Vorticella microstoma* (XXIII. 10–14).

Among cysts of the usual form and dimensions, are some in which a sac, not uniformly adherent to the inner surface of the capsule, contains from two to eight, or, more generally, from four to six, oval or reniform secondary sacs, irregular both in position and size (XXIII. 10, 11), and containing a dull and fine or coarse granular matter, within which, again, is a clear (contractile?) space, but no nucleus is discoverable even when acetic acid is added. Presently these vesicles elongate, and, becoming flask-shaped, protrude their necks through the enclosing sac and the cyst-wall (XXIII. 12, 13), and proceed to discharge their contents (XXIII. 14) through their open extremities; after which, they corrugate and wither. The discharged matter is composed of a mass of monadiform corpuscles united together in a globose gelatinous mass, the whole of the organic matter filling the cyst being used up.

A precisely similar act of propagation Stein also witnessed in an encysted *Vorticella nebulifera*. Cienkowsky (*Zeitschr.* Band vi. p. 381) also reports its occurrence in *Nassula viridis*, Duj. (XXVIII. 65–71); according to this author's researches, the contents of the cysts of *Nassula viridis* break up into a number of globular cells (XXVIII. 68–70), which soon partake of a certain degree of rotating movement among themselves, develope in their interior a multitude of what he terms swarm-spores, and at a certain period, when mature, severally produce, in turn, a tapering neck-like tubular process (XXVIII. 68, 69), which perforates the softened cyst-wall and gives exit to the spores or germs (XXVIII. 71). This account tallies with that given by Stein of certain *Vorticella*-cysts. Lachmann has the following remarks on this topic (*A. N. H.* 1857, xix. p. 238):—"It was only in his most recent observations on *Vorticella microstoma*, that Stein saw the production of larger globules, 'daughter-vesicles' (*Tochterblasen*), in the interior of the mother-vesicle; but previously he had seen nothing of the kind: it must remain uncertain whether he had overlooked them, whether, instead of several globules, only one very large one, entirely filling the mother-vesicle, had been produced, or whether two different modes of development actually occur in this case. This is the only mode of reproduction of the Infusoria which has hitherto been observed in encysted animals alone; but some observations made by E. Claparède and myself upon an undescribed vaginicolous Infusorium, indicate that encystation is not a necessary condition even for this mode of propagation."

The last plan of generative development to be considered is that wherein, according to Stein's hypothesis, the encysted animalcule undergoes an actual metamorphosis, and subsequently, as a rule, produces an embryo which, although very dissimilar to the original ciliated animalcule, is nevertheless presumed to be convertible into it after passing through one or more transitory phases of existence.

This cycle of life, or, according to Steenstrup's hypothesis, this "alternation of generation," in the generative acts of ciliated Protozoa, Stein has most diligently sought to establish as a fact, but, in the opinion of most of the best naturalists, has failed so to do. Still the hypothesis is too curious and interesting to be omitted from our description, and, what is more, has been adopted as true by several observers. It will therefore be best, first to set forth Stein's own account, and then to add the remarks and objections of others.

On some of the branching stems of *Epistylis plicatilis*, and of *E. nutans*, Stein encountered not only the ordinary animalcule in full activity and in a contracted state, but also some pear-shaped bodies, presenting merely the ordinary nucleus and a contractile space, without mouth or any remnants of the alimentary tube or of food. On other branches, again, were other bodies having the figure of *Acinetæ*, furnished with tentacles slightly moveable and more or less retractile (XXVII. 17, 18, 19, 20). These Acinetiform beings were noticed and figured by our countryman Baker a century ago; they, moreover, did not escape the observation of Ehrenberg, in the allied genus *Opercularia*, but were regarded by him as parasitic animalcules.

On another occasion, Stein met with a stem of *Epistylis plicatilis* bearing some thirty *Acinetæ*, differing among themselves very much, both in size and in their stage of development. Each was supported on a branch presenting the characteristics of this species, but smaller in dimensions, and tapering from the base of the Acinetiform body (where it had the usual thickness of an *Epistylis*-stalk) to its junction with the stem below. The length of the branches also varied greatly, being in some instances not quite so much as that of the body they supported, in others twice as long; however, there was no proportion between the length of the stem and the size of the body. Most of the *Acinetæ* had a smooth surface and no tentacula; they were of a pyriform compressed figure, and contained a coarsely granular and homogeneous substance, two or three irregularly-placed contractile spaces, and a central nucleus having either the normal horse-shoe- or an elongated oval shape. Where the *Acinetæ* had tentacles, these processes were few and small, and the surface of the body thrown into irregularities by its contractions; their nuclei were either round or oval. These *Acinetæ* exhibited no movements, except some slight ones affecting the tentacula. Were their anterior extremity unfolded and their tentacles outspread, they would assume the figure presented by those described in the first observations on this species, whilst the closed pyriform bodies were precisely alike.

The further developmental history of this particular *Epistylis* could not be followed out, and to arrive at the purpose of its *Acineta*-metamorphosis, the research was extended to other species. A particular form of *Acineta* occurs in company with *Epistylis digitalis*, which Stein concluded to be derived from it by a similar process to that presumed in *E. plicatilis*, although the *Acinetæ* were isolated and seated on short pedicles. At the anterior part of each *Acineta*, amid the large granules crowding the homogeneous contents, were a contractile space and, in many specimens, a moving embryo having a cylindrical figure, rounded at each end and narrower in the middle, where several zones of long cilia, in apparent folds of the surface, surrounded it. In general characters it would, as an independent organism, be referable to the genus *Trichodina*, and is probably no other than the *T. vorax* or *T. grandinella*, Ehrenberg. The embryo escaped through a temporary opening, which closed very speedily afterwards, leaving the animal apparently uninjured; moreover the tentacles, which are retracted during the birth, were again outstretched. The conclusion arrived at is, that the *Acineta*-condition is specially provided to carry out embryonic development, and that in so doing the *Acineta* gradually exhausts itself.

Stein's first impression was, that the embryo resulted from the development of the entire nucleus, and that this organ was formed anew from the general contents of the *Acineta*; however, later researches lead him to believe that only a portion of the nucleus is concerned in building up the embryo. No particular season seems devoted to this *Acineta*-formation, since Stein has observed it from the middle of March through the whole summer, and in fewer instances until December; moreover, embryonic generation is not restricted to any particular size of *Acineta*, but occurs in all except the very smallest; nevertheless the embryo is smaller proportionably to the decreasing size. Active embryos were seen in *Acinetæ* of only $\frac{1}{64}'''$, the germ itself being only $\frac{1}{250}'''$.

Besides the cysts and *Acinetæ* supported on branching *Epistylis*-stems, Stein found others attached separately by very short stalks, or nearly sessile; these, his observations go to show, are probably derivable from the beings produced by fission or gemmation, which have detached themselves from the parent-stem in the strongly-contracted or partially-encysted condition, and, on afterwards fixing themselves, proceeded either to complete their encysted state or to assume the Acinetiform condition.

Another set of beings Stein is disposed to introduce in the developmental history of *Epistylis digitalis*, in the shape of miniature branching *Vorticellina*. The branches are dichotomously disposed, very slender, short, and rigid. Seated at the extremity of each is a small campanulate being, with a stiff bristle proceeding from each angle of the base (XXVII. 22, 23). Internally they are finely granular. They exhibit slight changes of outline and jerking movements upon their stalks; they, moreover, can detach themselves and swim freely away like a detached *Epistylis digitalis*, and may sometimes be seen to affix themselves again by their base and produce a pedicle. These beings, whether derived from *E. digitalis*. or from *Carchesium pygmæum*—for they occur in company with both these animalcules,—their discoverer would regard as their earliest phase of development, and believes that not improbably similar miniature beings belong to all the pedicellate *Vorticellina*. This notion involves no great stretch of the imagination; for there is no extraordinary metamorphosis necessary, and we may throw out the suggestion that such minute *Vorticellina* are developed from the monadiform contents of the brood-cysts.

To take another illustration of Stein's hypothesis from the allied genus *Opercularia*—the *O. berberina*. Direct observation is wanting to identify the *Acineta* as belonging to this *Opercularia*, except so far as contiguity on the same filament of a plant or on the same member of a marine animal, and their frequent occurrence, be allowed to have weight. Stein argues that the conversion of an encysted *Opercularia* into an *Acineta* is readily conceivable, by reason of their congruity of form and the existence of intermediate phases, whilst, on the contrary, the transformation of the ciliated embryo into an *Acineta*, without first passing through the intervening stage of an *Opercularia* (a change easily imagined), is a circumstance scarcely probable: on similar grounds he would associate the pear-shaped *Acineta*, having a ramified nucleus (XXX. 3, 4), with *Opercularia articulata* (XXX. 1), as a phase of existence interposed between it and its embryonic stage of a free ciliated animalcule; but his developmental history of *Vorticella microstoma* is by far the most elaborate, although much too long to present here except in abstract.

His first step in the investigation of this species was the illustration of the act of encysting (XXVII. 5 *a–d*) in its widest range, and the next, to identify certain globular cysts, found in company with the *Vorticellæ*, with the cysts of those animals. These cysts were about $\frac{1}{50}'''$ in diameter; they had a clear double outline, and contained a homogeneous, transparent, colourless and granular substance. In most, the characteristic band-like nucleus and contractile space were visible, together with, in many specimens, the involuted ciliary apparatus and oral cavity, looking, as a whole, like a fissure at the anterior part of the cyst (XXVII. 7, 9). In other cysts, again, nought could be discerned save the nucleus and the contractile space, sometimes divided (XXVII. 1, 8); and lastly, in others, all distinction of organs was lost, the nucleus being the last to disappear (XXVII. 9).

Stein considered, at first, those peculiar capsules to be connected with the process of reproduction, and, from meeting with torn empty sacs, supposed that the interior was broken up into germs which made their escape through the walls. With this interpretation, however, he was not satisfied; and at the same time his attention was aroused to the circumstance of *Vorticellæ* occurring so frequently in company with *Actinophrys* and *Podophrya*, and to that of the increase in the number of the one as that of the other decreased. He therefore applied himself to watch the changes going on in the cysts described, and at length satisfied himself of the intermediate changes in their transition into *Actinophrys* or *Podophrya*—two varieties of the same animalcule, in his opinion, and not two genera, as usually represented. Stein was brought to the conclusion that this transition takes place, by comparing *Podophryæ* at an early stage of development with metamorphosed *Vorticella*-cysts. Among *Podophryæ* of the common form, examples occurred having their usually wide rounded capsule produced into a hollow funnel-shaped pedicle, and thrown into annular folds, alternating with acute, parallel, angular ridges (XXIII. 3). Most of these individuals were unarmed; but some had numerous capitate tentacles. On the other hand, old *Vorticella*-cysts were found in which the enclosed animal had detached itself from the cyst-wall, and become thrown into sinuosities and elevations, the latter of which pressed against the wall, threatening to rupture it. These and the above-described *Podophryæ* Stein supposed to merge into one another. The leading changes noticed in the encysted *Vorticellæ* consisted in the disappearance of the nucleus, in the multiplication of the contractile spaces, and in the detachment of the contents from the walls of the cyst (which they no longer completely filled), and their disposition into irregular and changing lobes. Thus far, in detecting such *Vorticella*-cysts, Stein proceeds by direct observation; but his next step is simply hypothesis, viz. supposing their contents to shoot out tentacula through the dense capsule, and assume the figure of *Actinophrys* or of *Podophrya* (XXIII. 1, 2, 4, 18, 19). That the metamorphosis should at one time be into the one generic form, at another into the other, he endeavours to explain by assuming that where no resistance is offered on any side to the developing Actinophryan, it assumes the form of an *Actinophrys*, but where resistance occurs at one point, it there developes a stem and becomes a *Podophrya*. To countenance his hypothesis further, he appeals to the great similarity between the *Acinetæ* met with in company with *Vorticella nebulifera* on duck-weed, and *Podophryæ*—so great, he says, that when the former are detached, it is difficult to know them from *Podophryæ*.

Granting that the history of metamorphosis is thus far complete and satisfactory, it remains to show what becomes of the Actinophryans thus transformed from the cysts of *Vorticellæ*, and to reply to the question whether they originate a generative act. At the outset of this inquiry Stein finds himself at variance with Kölliker and others respecting the structure and vital endowments of *Actinophrys*. The writers referred to state *Actinophrys* to receive food within its interior, to excrete undigested matters, and to exhibit certain powers of locomotion; these peculiarities Stein ignores, and insists on identifying the Acinetiform beings he has encountered with *Actinophrys Sol* and *Podophrya fixa*, which, he affirms, give birth to a ciliated embryo.

This embryo, he asserts, is produced within a defined cavity, so far larger than itself that it can move within it (XXIII. 2, 4, 5). Its figure is pear-shaped with a central constriction, and several folds occupied by cilia; and it appears composed of a finely-punctate sarcode, containing, in the axis of its posterior and larger segment, an oval or band-like nucleus, and near to this a circular actively-pulsating space, and occasionally, on the other side of the nucleus, a second smaller one. No mouth could be detected. The being, as a whole, very closely resembles a detached gemma of *Vorticella microstoma*, into which it can be very easily conceived to be changed, on fixing itself by its anterior end and then developing, in its larger and hitherto posterior segment, a mouth and ciliary wreath.

After lively rotary movements within what might be called its uterine cavity, the embryo escapes with a sudden bound, and gains a free, active existence. The passage by which it has made its way through the substance of the parent *Actinophrys* continues for some time open, but is gradually closed up from behind. The size of the embryo is proportioned to that of the parent, and varies between $\frac{1}{150}'''$ and $\frac{1}{83}'''$. The diameter of the smallest parent being in which a mature germ presented itself, scarcely exceeded $\frac{1}{75}''$.

One other instance will suffice to illustrate Stein's hypothesis of Acinetiform transformation. The one we select is the *Vaginicola crystallina*, which that author attempts to show becomes, by a metamorphosis, *Acineta mystacina* (XXVII. 10–15). Out of a large number of specimens contained in a vessel of water, few could be found at the end of fourteen days, the place of the great majority having been assumed by *Acinetina*. This occurred even when great pains were taken to isolate a certain number of *Conferva*-filaments richly covered with *Vaginicolæ*, and to place them in pure spring-water, so as to avoid the introduction of other colonists. That the *Acinetæ* were derived from the *Vaginicolæ*, a comparison of the structure of the two will indicate. The contracted body of the *Vaginicola* may be recognized in the *Acineta* detached from the bottom of its sheath and raised to the upper part, which it completely fills,—the mouth of the sheath having previously been bent inwards over it as a cover, and a layer of gelatinous matter poured out to bind the two together. The outermost parts of the roof-like cover project freely above this layer, and are traversed by several radiating folds or fissures. The clearest notion of the transformation effected is obtained when we can look down upon the top surface of the capsule, by getting the axis perpendicular to the eye.

The contained body is closed in on all sides; and its contents are substantially the same as those of the body of the *Vaginicola* (XXVII. 12), with numberless fine granules, and sometimes with a preponderating number of large granules scattered through them, rendering the body opaque and of a greyish-yellow colour. There is likewise a similar round contractile space; but instead of a band-like nucleus, there is a rounded one. This difference in respect of the nucleus is not important, inasmuch as its length varies greatly in *Vaginicola* according as the animal is extended or in a contracted state,—being in the latter much shortened or merely elongated-oval, whilst in the former its length exceeds two or three times its width. Hence it is in no way remarkable that, in the very contracted condition of the encysted and Acinetiform state, the nucleus should be very much shortened and rounded,—a change which analogy, indeed, with various encysted animals would lead us to anticipate.

From the upper surface of the encysted body very many bristle-like tentacles with knobbed ends are given off, which penetrate the gelatinous layer through the fissures in the cover of the sheath, and outspread themselves in a radiating manner. These tentacles are for the most part straight, and slowly extend and retract themselves in length. Pressure causes their contraction, and huddles them together; but they are not entirely withdrawn. Some smooth Acinetiform specimens are met with, which may be considered to be in an earlier stage, and similar to the incomplete *Acineta* of *Epistylis plicatilis*.

The origin of the *Acinetæ* from *Vaginicola* is further substantiated by the relative dimensions of the two. Thus *Vaginicolæ* were found on *Conferva* having sheaths betwixt $\frac{1}{60}'''$ and $\frac{1}{24}'''$ in length; those most common were from $\frac{1}{40}'''$ to $\frac{1}{30}'''$ in length and $\frac{1}{70}'''$ in width. The height of the capsule of the *Acineta* was from $\frac{1}{83}'''$ to $\frac{1}{32}'''$, and its width not much less. Moreover, intermediate phases between *Vaginicola* and *Acinetina* were met with,—as, for instance, capsules occupied anteriorly by the contracted body, which still exhibited, upon being moved up from the bottom of the case, the posterior annular furrow and traces of the ciliary wreath previously existing, and had its anterior half enveloped in a gelatinous lamina, uniting it to the inner surface of the sheath, which was at one time more, at another less, incurved upon the animal, but had as yet not been converted into the peculiar pent-house-like cover.

The metamorphosis, therefore, of a *Vaginicola* into an *Acineta* may be thus explained. The animacule is in the first place contracted in the ordinary manner; it then developes its posterior furrow and ciliary wreath (XXVII. 11), and, detaching itself from the bottom of its sheath, rises to the upper part, which it entirely fills and closes up. From this time the rotary apparatus and digestive tube disappear by absorption; the excretion of the gelatinous matter from the fore part ensues, and fixes the animal in its position, while its tendency to fall to the bottom of the case, and to contract, draws inwards the mouth of the case, and completes its enclosure within a shut sac or capsule (XXVII. 12). The contractile tendency of the body still continuing to operate, brings about a narrowing of the anterior part, and with this a consequent elongation of the sheath; in this way an explanation may be given of the very long specimens frequently encountered. The extrusion of the tentacles is an after-occurrence (XXVII. 13).

The complete *Acineta* can entangle small Infusoria with its tentacula, which, by their crossing and retraction, draw the captured particles to the surface, where probably their nutritive matters are absorbed through it; at all events, no food or foreign particles are seen in the interior.

Stein next attempts the identification of this *Acineta* of *Vaginicola crystallina* with the *Acineta mystacina* of Ehrenberg, and in a subsequent paper proceeds to show that it developes within itself a ciliated embryo. Amid many *Acinetæ*, he discovered some bearing a clear oval or rounded cyst, or, less commonly, several such, upon the surface of the enclosing lid; where there was a plurality, they were evidently in different stages of development. The cyst contained a sharply-defined Infusorial being, of a homogeneous finely-granular substance, and having an actively-pulsating sac. At first Stein imagined these might be animalcules casually affixed to the *Acinetæ*; but further observation proved their organic connexion with, and derivation from it.

The cyst-walls were internally soft and gelatinous, and their substance continuous, through the fissures of the cover, with the gelatinous layer of the *Acineta*, of which they might be more correctly represented pouches or diverticula. The appended animalcule is not a bud produced from the *Acineta*-body; for it is never found in organic connexion with it, but undoubtedly has its origin as a germ within it, and makes its way outwards. In fact, it is developed from the rounded nucleus by its elongation and subsequent transverse fission. The youngest cysts are round or shortly oval, and have no other indication of life and movement than that exhibited by the contractile space. In the next stage they are slightly emarginate at one end and still motionless, whilst in the oldest the fissure or emargination extends deeply into the interior in a curved manner, and very clearly exhibits a number of vibratile cilia. In this mature state they enjoy considerable locomotive powers within their capsule, and recall in their form that of contracted *Vorticellina*. Thus, at their fore part they present a rounded ciliated lobe, resembling somewhat a retracted rotary organ, whilst the fissure extending inwards indicates the alimentary tube.

There is yet another apparent mode of embryonic development in the *Acinetæ* of *Vorticellina* described by Stein, which occurred in some specimens not provided with tentacles. In place of these, one or two short closed tubular processes extended from the fore part of the animalcule; of the usual granular contents scarcely a trace remained; and the nucleus and contractile space had entirely vanished. The membrane of the enclosed body, thus deprived of its ordinary constituents, contained, in their room, six elongated-oval cell-like bodies, $\frac{1}{50}'''$ long, which seemed to have been developed at the cost of the contents of the original *Acineta*. These structures had a sharp outline, and contained a coarse granular substance and a contractile sac. They seem to develope into embryos; for in one case a ciliated furrow was observed, assimilating the being to the more usual embryos of the *Acinetæ*. Probably the *Acineta*-condition of the *Vaginicola* is terminated in this manner, after developing for a period embryos according to the plan above mentioned, by the final breaking up of the nucleus into several large germs.

In addition to the species described, Stein believed he made out the *Acineta*-state of several other species of *Vorticella*, of *Epistylis*, and *Opercularia* (XXX. 1–4), as well as of *Zoothamnium*, *Ophrydium* (XXX. 5–8), and *Spirochona* (XXX. 18–26). However, sufficient details have been given to illustrate the presumed fact in the developmental history of the Ciliated Protozoa; and we must refer those of our readers desirous of more fully testing the views of that most excellent observer, to his often-cited work, 'Die Infusionsthiere auf ihre Entwickelungsgeschicte,' Leipzig, 1854. Moreover, the several new forms of *Acinetina* he has pointed out will be found referred to in the general history as well as in the systematic views of that group.

It is now incumbent on us to review the opinions of other naturalists upon this remarkable and interesting hypothesis. A few have accepted it, among whom are Mr. Busk (as we gathered from his lectures at the College of Surgeons in 1857) and Mr. Carter. The latter has the following remarks on the subject (*A. N. H.* 1856, xviii. p. 237):—"I could not discover an elongated nucleus, as Stein has figured, in the *Amœbæ* and *Acinetæ*, which I saw developing young *Vorticellæ*, the former in plurality (one to three) and the latter singly: if present in the Amœbous form, it was circular, and if in the *Acinetæ*, undistinguishable from the general 'granulation.' Again," he goes on to say, "where are these transformations to end? Into what kind of Rhizopods do the sheathed *Vorticellæ* pass? How many of the freshwater *Rhizopoda* are alternating forms of *Vorticellæ*?" At the time of his writing the above, Mr. Carter had not seen Stein's latest work, which would have resolved some of the doubts and queries expressed. Thus, the German naturalist finds the nucleus, if elongated and band-like in the encysted being, to become orbicular or oval when in an *Acineta*-state, and points out that acetic acid will reveal this organ when obscured by the granules of the interior. Moreover, his later researches have been extended to sheathed *Vorticellina* or *Ophrydina*—for instance, to *Vaginicola*, of which we have given the particulars. However, it is very important to obtain Mr. Carter's statement that he has seen young *Vorticellæ* developed from *Acinetæ* and *Amœbæ*,—intending by the latter, we apprehend, *Acinetæ* without tentacles and capsule, and not the simple *Amœbæ* commonly understood by that term.

The objectors to the hypothesis are by far the more numerous. The eminent physiologist Johannes Müller, to whom Stein showed *Actinophrys* and

Podophrya developing embryos, could not agree with the conclusion the latter arrived at (viz. that they became *Vorticellæ*), but was more disposed to believe that they relapsed into *Acinetæ*. Ehrenberg (*Ueber die Formbeständigkeit und den Entwickelungskreis der organischen Formen*, Berlin, 1852, at pp. 23, 24, and 34) attributes the theory to erroneous and hasty observation. The supposed embryo of *Acineta* is, to his apprehension, simply a *Trichodina* which has been swallowed. To these strictures Stein replies that the *Acineta*-bodies have no mouth, that they never contain any foreign matters taken as food, and that no more than one *Trichodina* appears in them at a time, although many may live around them, and several would, no doubt, if taken as food, be often found together in the interior. It is, moreover, to be noted, that *Acineta* collected from the most different localities contained the self-same *Trichodina*-form, and that such forms occurred in sparing number. Again, it must not be forgotten that the embryo may be watched in active movement within the *Acineta* for the space of an hour, whereas Infusoria swallowed by other animalcules are speedily reduced to a state of rest and destroyed. Lachmann rejects the hypothesis, and gives, in much detail, his reasons for so doing. At the same time he confirms the fact of "the formation of embryos, not only in many *Acinetina*, but also in numerous other Infusoria" (*A. N. H.* 1857, xix. p. 232), and attests the fact of the nucleus being primarily concerned in this act of development, adding some particulars which require to be recorded. "The nucleus," he writes (*loc. cit.*), "is usually seen, first of all, to divide into two or more parts, when the same processes take place in one or several of these parts, which in other cases occur in the undivided nucleus. Upon or in the wall of the nucleus, or of one of its products of division, we now sometimes perceive small round globules, which increase in size, finally acquire a contractile vesicle, and become converted into embryos; these at last become furnished with cilia, escape out of the parent animal, and swim about freely, generally in a form more or less differing from that of the mother. Very different numbers of embryos may be formed in one section of the nucleus; in the same species we sometimes find many, and sometimes only one embryo formed in it; and an embryo which has been developed alone in a fragment of the nucleus is usually as large as all the embryos formed in a similar fragment which has developed many of them taken together.

"The true import of the nucleus, of course, is not decided by this statement; [we cannot say] whether it is to be regarded as a germ-stock, in which germs are formed asexually, as an ovary, in which the ova are developed at the same time, or, in accordance with Focke's views, as a uterus, in which the ova or germs formed in another place (perhaps in the nucleolus?) are further developed.

"The fate of the embryos which are unlike their parents after their birth is still unknown in most cases."

Perty displays distinct opposition to Stein's views, but has not thoroughly examined them, contenting himself with an occasional critique in passing. For instance, he states that those miniature beings regarded as the brood of *Vorticella*, both by Stein and Ehrenberg (*see* p. 357), are in his opinion no more than specimens of *Cercomonas truncata* (Duj.). Again, he remarks, *Epistylis anastatica* is very rare at Berne; and the *Trichodina grandinella*, which Stein represents to be its embryo, is very common in every collection of water; also *Vorticella microstoma* is most abundantly distributed, but its supposed metamorphic condition, viz. *Podophrya*, very uncommon. Respecting the latter animalcule, and likewise *Actinophrys*, he adds an observation of his own, which convinced him of the reproduction of these animals by minute internal germs, which, when set free, immediately assumed the special characters of their parents (*Kleinste Lebenform.* p. 74).

To Dr. H. Cienkowsky we owe the latest examination of this subject (*J. M. S.* 1857, p. 96). He rejects Stein's theory because, instead of finding *Podophrya fixa* in company with *Vorticella microstoma,* he met with it in great abundance along with multitudes of *Stylonychia mytilus* and *St. pustulata.* Having watched its process of encysting, he felt "unable to adopt Stein's view, that the *Podophryæ* are enclosed in a membrane of which the slender peduncle is simply a tubular process." In fact, he noticed cysts in which the original slender peduncle was appended to the sacculate envelope. He also traced, step by step, from *Podophryæ*, the derivation of the supposed transitional stages between *Vorticella*-cysts and *Podophryæ,* and asserts "that they are most certainly *not* metamorphosed *Vorticella*-cysts, but the commencement of the encysting of *Podophryæ. Podophryæ* are not formed out of them; but, on the contrary, from the latter arise the forms above described, which Stein looks upon as *Podophryæ* remaining at an early stage of development. The metamorphosed contents of older *Vorticella*-cysts, regarded by Stein as the first commencement of the formation of a *Podophrya,* indicate, according to what I have seen in other infusorial cysts, and to what Stein himself states with regard to *Vorticella microstoma,* the commencement of the breaking up of the entire contents into numerous smaller 'swarm'-cells."

Dr. Cienkowsky's next proceeding was to show the relations of the motile embryo developed from the Podophryean animalcule Stein met with. He encountered numerous *Acinetæ* precisely like those figured by Stein. "Most of these *Acinetæ* were without peduncles, and had no limitary membrane, although numerous specimens might be seen with a short peduncle and imbedded in a mucoid thick envelope; and this was especially observed when the *Acinetæ* had lived for about a week on the object-glass (XXIII. 33-39). Although numerous points of relation exist between these *Acineta*-forms and *Podophrya fixa* (Ehr.), I am nevertheless unable to determine whether they should be regarded as identical, or, with Stein, whether *Podophrya* and *Actinophrys* should be considered as the extreme links in the morphological cycle of one and the same species (Stein, *loc. cit.* p. 143). The peduncle of an *Acineta* is a tubular elongation of the enveloping membrane, whilst in the membraneless *Podophrya* it is an independent formation. When the *Podophryæ* are left in water for a few days upon the object-glass, they form the very characteristic pedunculate cysts; but, under the same conditions, I have never been able to follow the *Acineta*-forms now in question to the formation of cysts; the former multiply by division, whilst in the *Acinetæ* I have never noticed the occurrence of that process. What Stein describes as *Actinophrys* is really a non-pedunculate *Acineta* ; the *Actinophryæ* have no tentacles, but setæ, though perhaps occasionally some of these setæ are capitate. In almost every specimen of the *Acinetæ* in question might be seen rotating a round or oval embryo, of various size and position, with one or two contractile spaces. This embryo slowly approached the wall of the *Acineta,* caused it to protrude a little outwards; and after remaining for a short time quiescent, it slowly made its way through the wall (XXIII. 41), and quitted the parent site with the rapidity of lightning when it had freed about half of itself. This rapidity was so great, that the course could not be traced with a magnifying power of 170 diameters. About five minutes elapsed from the commencement of perceptible motion to the complete liberation of the embryo; and on many occasions I saw two rotating embryos liberated in succession. When the embryo is half out of the parent-cyst, a transverse ring of very fine vibratile cilia may be perceived at a short distance from its summit."

This rapidly-moving embryo was followed in its course, under "the microscope, and was seen to traverse" the drop of water from one side to the other, in divers straight and undulating lines, as quick as lightning. Upon meeting a mass of mucus on the edge of the drop, it bounced back again, repeating the manœuvre on each occasion of the same kind; sometimes, though more rarely, the movement was circular, around the margin of the drop.

"Judging from what I had noticed in the division of the *Podophryæ*, I expected that the movement would not be of long duration. But after a continuous observation, for fully five hours, of the active motions of the tiny brilliant point, a determination of blood to the head obliged me to desist.

"A fresh drop of the infusion, in which two embryos were in active motion, was observed at intervals of a quarter of an hour. At the end of five hours, the rapidity of the movement was notably diminished—it became tremulous, and then, perhaps, for a time, as rapid and energetic as before. I now placed the object under the compound microscope, and continued my observation of the indefatigable embryo for another quarter of an hour; the embryo became stationary. I waited with drawn breath what would come next: its form from oval became spherical; at the border appeared short, thick, equidistant rays, which, after a while, were developed into elongated, capitate tentacles; the contractile space was visible; and I could no longer doubt as to the *Acineta*-nature of the creature (XXIII. 42, 43). This observation was twice repeated.

"It can, therefore, no longer be doubted that from the *Acineta*-embryo, after a prolonged motile stage, another *Acineta* is formed. My observations do not, of course, show that it is impossible that the motile *Acineta*-embryo should be transformed into a *Vorticella*, and a *Vorticella*-cyst into an *Acineta*; but the field of possibilities is very wide; everything is possible if it only be founded on facts. I believe, therefore, that it may justly be concluded that Stein's Acineta doctrine, as concerns *Vorticella microstoma* (Ehr.), must be regarded as *hypothetical*, and not based upon facts."

Lachmann and Claparède have jointly examined into the facts and appearances upon which Stein's hypothesis is based, and have presented an abstract of their views, which are entirely adverse to it, in the *Annales des Sciences Naturelles*, 1858, in anticipation of the publication of their essay, to which the French Academy awarded the first prize for original researches into the development of Infusoria. They state that they have witnessed the development of embryos in many other *Acinetina* besides those recognized by Stein; that the embryos of different species vary; that the tentacles of *Acinetina* are suctorial and active in seizing food, which is absorbed with avidity into the interior; and that the internal organization of those animalcules is in all probability more elaborate than Stein supposed.

The appearance of the joint essay on the development of the Infusoria, by the gentlemen mentioned, as well as of that by Lieberkühn, which shared in the prize offered, will be anticipated with much eagerness and pleasure by all naturalists who feel how obscure and confused is the present state of information on the subject.

At the present time, we may say that Stein's hypothesis of the transformation of Ciliated Protozoa (or, more strictly, of the *Vorticellina* and *Ophrydina*, to which alone it has been sought to refer it by observation) remains unproven; yet doubtless it is a step in the right direction to arrive at a knowledge of the true generative process of these animalcules, and has already proved the development of ciliated embryos in *Acinetina* and in various Ciliata.

The history of the metamorphoses of *Trichoda Lynceus* recounted by M. Jules Haime (*Ann. d. S. N.* 3 sér. xix. p. 109) calls for notice in this place, although we are not disposed to assign it much value, inasmuch as some of the phenomena stated are very extraordinary, are unsupported by any parallel facts, and are in actual opposition to those best ascertained respecting the organization and functions of the Ciliata. We would especially direct attention to the statement of the exudation of sarcode, and the consequent reduction of size, as a necessary step in the developmental phases,—an occurrence, in our belief, without analogy and quite anomalous.

He first asserts that "*Oxytricha* (Ehr.) is a larval phase of *Trichoda Lynceus*, and next that, on its fissiparous division, generally one of the two segments produced assumes a globular form, losing almost all its appendages, both cilia and setæ, and, at the same time, gives exit to successive portions of its sarcode, so that vacuoles multiply in its interior. At this stage a gelatinous cyst is excreted around it which ultimately hardens into a membranous envelope. In a short time the contents of the cyst shrink from the cyst-walls and leave a space around them, when ciliary movement appears at one part, and, a further escape of granular sarcode having taken place through the cyst-wall, the figure becomes more or less modified. Two portions are now distinguishable within the cyst—a ciliated embryo and a mass of effete granular matter; and, as time elapses, the former seems to grow at the expense of the latter, and eventually makes its escape from the nearly-emptied cyst. The freed animalcule is not at first very different in appearance from the parent *Oxytricha*, although only about two-thirds its diameter; but ere long it developes itself into a very different being. In so doing, it first exudes some more of its substance, then produces numerous short stiff setæ to serve it as feet, acquires a hard integument in the form of a shield, or carapace, and forms a mouth, in the form of a slit on one side, and, in front of this, a gyrating filament to produce a current for the introduction of food. In this transformed being the *Aspidisca* (Ehr.) is recognizable, having a very much smaller size than the original *Oxytricha*. The reversed course of development, viz. that of *Aspidisca* into *Oxytricha* has not been followed; but it may be conjectured that a sexual process is interposed, probably in connexion with other metamorphoses."

Before taking leave of the subject of reproduction among the Ciliata, it is important to add a statement made by Lachmann in his excellent and oft-quoted essay (p. 239). He writes—"With regard to the peculiar process of copulation or zygosis of the Infusoria, as its object is still entirely unknown, I shall only state that, except in the *Diatomaceæ* and *Desmidiaceæ*, the position of which is still doubtful, it has hitherto been observed particularly in *Actinophrys* and *Acinetina*. According to an oral statement, E. Claparède has also seen *Vorticellina* (especially *V. microstoma*) in zygosis; and I have twice met with double animals of *Carchesium*, still sitting upon a double stalk and constantly becoming more amalgamated, so that the cavities of both the fused animals communicated, and the morsel which was passed from the pharynx of one animal usually ascended in the cavity of the other, up to the lower surface of its ciliary disk. The rotatory organs remained separate; and after the lapse of some time, the double animal cast itself loose from the stems, and swam about for more than twenty-four hours by means of a circlet of cilia, which was produced around the rounded hinder extremity formed by the coalescence of the two posterior extremities of the individual animals."

NATURE OF THE CILIATED PROTOZOA. THEIR EXISTENCE AS INDEPENDENT ORGANISMS. CELL THEORY APPLIED TO THEM.—That the beings we have comprehended under the appellation Ciliated Protozoa are indubitably animals, has never been called in question; nevertheless their claim to be considered independent organisms has been challenged by a few naturalists, who insist on their being generally nothing more than phases of development of animals more or less elevated in the scale. These objectors have, however, hitherto failed to produce sufficiently direct and exact observations in proof of this general assertion, which rests mainly upon presumed external resemblances, and on analogy with many of the inferior animals, among which the so-called "alternation of generations" is the rule. In the foregoing pages there is certainly sufficient evidence that some Infusorial forms are merely stages of development of others; and nothing is more probable than that some may similarly be phases of animals belonging to other classes than the Ciliata; yet, on the other hand, the independent character of several families (for example, of *Vorticellina*, *Ophrydina*, and *Colepina*) has not been at all shaken by the researches of naturalists.

There is, we believe, a true typical organization appertaining to the Ciliata, of a distinct character from that of other animal organisms, and inconvertible. It may be more or less perfected, or more or less degraded, and may, in the process of development, be put in abeyance for a time, though not replaced by another; and under this impression, Stein's views of Acinetiform metamorphosis have, to our mind, an air of improbability.

The very distinguished naturalist M. Agassiz stands among the foremost in advancing the sweeping conclusion, that the Ciliated Protozoa have no existence as a class. Most of the Enterodela of Ehrenberg, he says (*A. N. H.* 1850, vi. p. 156), "far from being perfect animals, are only germs in an early stage of development. The family of *Vorticellæ* exhibits so close a relation with the Bryozoa, and especially with the genus *Pedicellina*, that I have no doubt that wherever Bryozoa should be placed, *Vorticella* should follow, and be ranked in the same division with them. The last group of Infusoria—*Bursaria*, *Paramecium*, and the like—are, as I have satisfied myself by direct investigation, germs of fresh-water worms, some of which I have seen hatched from eggs of *Planaria* laid under my eyes." In these statements Mr. Girard (*Proceedings of American Association*, 1848, p. 402) coincides, and adds that *Colpoda Cucullulus* is one of the embryonic stages of fresh-water *Planaria*.

To these statements it may very fairly be objected, that the embryonic animalcules presumed to be identical with certain Ciliata may possess merely a deceptive outward resemblance, and, again, that in the case of the assigned affinity of the *Vorticellina*, an exact comparative examination of the organization of this family with that of Bryozoa will show that there is no true homology, but simply some general points of similarity, between them.

When Schleiden and others unfolded the cell-theory as a general fact in organic beings, attempts were at once made to apply it to the simplest animal structures, among which the Ciliated Protozoa are numbered. The Protozoa were called unicellular animals; a cell-wall, more or less modified, was everywhere discovered or supposed; and the more solid body, the testis of Ehrenberg, was at once assumed as the "nucleus." This name we have for convenience' sake retained, although its special relation with cell-structure and the cell-theory cannot, in our opinion, be sustained.

The cell-theory, in its application to Protozoa, found a very able advocate in Kölliker (*J. M. S.* 1853, i.), and was upheld by many others; its simplicity, and the generalization as to structure and function it suggested, recommending it to philosophic minds. Latterly, however, a more exact appreciation of the true organization and functional history of animalcules has caused the abandonment of the hypothesis, the greatest names in microscopic science having pronounced against it.

To sum up the leading circumstances opposed to the theory in question. The processes of the surface, both in variety of character and of movements, are not paralleled in any known simple cell; the same may be said of the pedicles and branched stems of *Vorticellina*, and of the sheaths of *Ophrydina*: the presence of a mouth, and, according to the descriptions of many excellent observers, of a discharging aperture or anus, and the involution of the external surface in the form of an alimentary tube, are facts irreconcileable with the idea of a cell. So, likewise, the beautiful and complicated ciliary apparatus of the *Vorticellina* and *Ophrydina*—the existence of cells, or at least of vesicles, in the interior—the reception of external matters into the general cavity, where they are either entirely digested or partially or wholly extruded again—and, lastly, the activity, persistence, and apparently voluntary character of their movements, are circumstances without parallel in the economy of simple cells. In the face of all these discrepancies in structure and function between the bodies of Ciliated Protozoa and simple cells—closed sacs, containing a nucleus amid their protoplasmic substance—it appears to us it would be a mere visionary notion to insist upon a homology betwixt the two. To conceive such a thing, the accepted idea of a cell must be set aside, and replaced by so loose and general a definition as would be worthless.

Without quoting their remarks, which is uncalled for here, the following observers may, among others, be cited in opposition to the hypothesis of the unicellular nature of the Ciliata: viz. Leuckart, Lachmann, Claparède, Perty, and Schneider. Our countryman, Mr. Busk, is, as we gathered from his lectures, to be reckoned in the number.

Conditions of Life.—Under this head we have to consider the habitats of the Ciliata, the usual conditions under which they live, their successive appearance in liquids, the influence of heat and cold, and of chemical agents upon them, and their probable duration of life.

The majority of the Ciliated Protozoa are inhabitants of fresh water; few are marine; or perhaps it would be more correct to state that few marine species are known. Cohn affirms that fresh water acts as a poison and kills the marine forms (*Entw.* pp. 132, 133); that the several genera of Enterodela (Ehr.)—*Cyclidium*, *Paramecium*, *Euplota*, *Oxytricha*, and *Vorticella*—occur in water holding organic matter in solution or decomposition; and that *Stentor*, *Ophrydium*, and *Loxodes* are found only where the water is pure and uncontaminated with dead matter. This statement must not be taken arbitrarily; for among the former series, specimens are constantly seen in water free from appreciable organic impurities. Moreover, in all cases, the aqueous medium in which the Ciliata live must contain a certain proportion of organic materials (either living in the tissues of minuter organisms, or in a state of transition, commencing decomposition or breaking up into mineral or dead matter), from which they can derive the elements of their nutrition.

Animalcules indeed, if we may so say, stand between the living and the dead, rescuing the atomic fragments of organic matter which are ready to perish and to lapse into the domain of dead matter. Thus we find them constantly in infusions, either artificially made by steeping animal or, more particularly, vegetable substances in water, or naturally occurring in ponds and ditches containing growing aquatic plants or their detached portions, or in the turfy hollows of commons and bogs. At times, indeed, the water in which they occur appears to the eye almost pure, and free from extraneous matters; but a closer examination will prove it to be inhabited by multitudes of monadiform existences, of minute plants, *Desmidieæ*, *Diatomeæ*, *Nostochineæ*, *Confervæ*, and *Algæ*, which are diffused throughout, or float upon the surface, or form a stratum at the bottom.

The attached forms find appropriate habitats upon the stems of aquatic plants, and very commonly upon the surface of various animals living in water; for instance, on the shells of Mollusca, such as the water-snails, and on the surface of the Entomostraca. A few species find a suitable locality within the interior of larger animals, of which, therefore, they are esteemed the parasites,—a fact illustrated in the genus *Bursaria*. This subject of the habitats of the several genera needs not here to be enlarged upon, since it recurs again and again in the generic and specific descriptions of the systematic division of our work.

The Ciliata do not so frequently constitute the colouring ingredients in water as do the Phytozoa. Nevertheless there are several species which make their presence known by their colour, either when collected in a stratum upon the surface of plants or of the water, or when generally diffused in a small pool. Thus *Stentor polymorphus* and *Vorticella chlorostigma* coat the stems of aquatic plants green, whilst several species of *Vorticellina* cover them as with a bluish-milky film, and *Stentor aureus* with an orange-coloured induvium. *Bursaria vernalis, Trachelocerca viridis, Coleps viridis, Glaucoma viridis,* and *Paramecium Chrysalis* are found dispersed through the water—the four first imparting to it a green, the last a milky tint. The greenish masses of *Ophrydium versatile* at times float on the surface, driven about by the wind, and at others are attached to the tendrils of roots and to the stalks of aquatic plants.

The distinct colours, such as green, yellowish-red, and orange-brown, are in all cases, we believe, not essential to the animalcules exhibiting them, but due to the food they swallow, and to its changes in course of digestion. These changes, as affecting the colour, have been illustrated in a preceding page (p. 310) in the instance of *Bursaria vernalis*, for which the *Chilodon ornatus* might have been substituted. Moreover, in *Nassula* the reddish-blue or violet spots, conceived to be glands by Ehrenberg, are apparently the product of digested *Oscillatoriæ* (p. 312).

Succession of Species.—If a fluid containing Infusoria be examined from time to time over a considerable period, it will be found that certain species disappear, and are replaced by others not before found in it. This succession of forms in the same liquid has been remarked from the earliest period of microscopic research, and has been the fruitful source of the wildest theories of the metamorphoses of Infusoria. Succeeding animals have been forthwith concluded to be the transformed states of previous ones, however wide the dissimilarity between them: no intermediate phases or transitional changes have been watched; but the conclusion that the one is derived from the other, has been jumped at without reserve. Some theorists have even proceeded further, and, like Unger, believed in the transformation of vegetable into animal life, or, like Laurent and Gros, have imagined the conversion of mineral matter into organized animalcules, and these last into beings of still higher position in the animal scale, such as Annelida and Crustacea.

A partial explanation of the succession of animal forms in a collection of water is to be found in the following facts:—

First, no vessel of water of ordinary dimensions can be so thoroughly examined but that some animalcules may be overlooked; the same accident will happen still more frequently with their minuter germs or embryonic conditions, or with their encysted state. The earliest phases, again, may, in their transient form, very nearly resemble certain known independent species, and be readily mistaken for them, or even for encysted simple plants. So, also, portions of plants, small aquatic animals, organic débris, and other substances in the water may conceal in their cavities or interstices either mature animalcules or their immature or encysted forms. Further, we know the air to be permeated by animalcular life; that every wind wafts organized beings, for the most part in an encysted state, together with germs and spores, animal and vegetable, to and fro; and every exposed collection of water, unless protected by the most careful and complex contrivances, must perpetually receive fresh colonists. Now, among all these mature, encysted, immature, and embryonic inhabitants of a portion of water, existing in it when first submitted to observation, or subsequently introduced into it from without, there must necessarily be a constant change in their relative abundance, and even in their continued existence in it. Mature individuals may die out, be devoured by other animals, or be otherwise destroyed before multiplying themselves, or may, by encysting and reproduction, develope beings of a different general character, *i. e.* undergo a real transformation; encysted beings may merge into life, immature and embryonic forms take on their perfect conformation; hidden organisms may come out from their concealment; or the new ones borne by the air may manifest themselves; and in these and other conceivable ways new series of inhabitants may make their appearance on the scene.

Lastly, the succession of species is greatly influenced by the changing conditions of the water and its contents, by atmospheric conditions—cold, heat, and electricity, and the moisture or dryness of the air. All the facts collected under the head of Habitats indicate the mutual relations between the appearance of certain animalcules and the presence of particular plants or even of certain animals, or the existence or absence of decomposing organic matter. We have, moreover, so to speak, carnivorous and herbivorous Ciliata, each and all severally requiring their special nutritive elements in the water. From these circumstances it is evident that particular species will disappear when the conditions favourable to them fail, to be in all probability replaced by others to which the change is favourable and necessary; for instance, the vegetable feeders will decrease and disappear when the minute plants on which they feed are consumed; so those animals requiring pure water will die out when decomposing organic matters multiply, and will be replaced by the forms which delight in their presence, but have remained undeveloped until the conditions favourable to their existence are brought about. The little *Coleps* (to give a particular illustration) delights in the eggs and contained substance of Entomostraca, and makes its appearance in company with those animals, without which it is only occasionally seen. And it remains to be noted, that unless an animalcule is duly supplied with appropriate nourishment, its reproductive powers remain in abeyance, and consequently its whole race may vanish from this cause.

A particular example of the succession of species may be quoted from Cohn's essay on Reproduction of Infusoria (*Zeitschr.* 1851, p. 258). In a vessel containing decomposing *Spirogyra*, at first appeared countless specimens of *Paramecium Aurelia*; these were replaced by the *Proteus* of Baker, either the *Lacrymaria Proteus* or the *Trachelocerca Olor* (Ehr.); these in their turn were followed by *Chilodon Cucullulus*, and after a few days by a *Colpoda*; afterwards large *Euplotes* with prominent green globules, probably a new species, and lastly, colourless specimens of *Euplotes Charon* exhibited themselves,—all these species following each other in succession in the course of three weeks, a new form appearing on the decline of a preceding, attaining its maximum in number, and then decreasing in its turn to make room for the next in the series. Moreover, this excellent observer remarks that a similar succession is observed in the case of microscopic plants, such as *Oscillatoria.*

Duration of Life.—What this may be among the Ciliata is little known to us. "The Infusoria have a comparatively long life" was one of the general facts enunciated by Ehrenberg. Under favourable conditions certain species have been known to live four or five weeks. This applies to them only in one phase of existence, viz. that which we regard as the normal and mature one. But when we take into consideration the encysting-process as an act of conservation, we are compelled to assign them a duration of life of a very much longer range; for by its means the Ciliated Protozoa are preserved in a quiescent, torpid, or hybernating state, not only over periods of drought when the ponds containing them may be dried up, but also during the entire winter.

Further, by the medium of fission and gemmation, the existence of the animalcule is prolonged or perpetuated through all the multiplied series of divisions and subdivisions and of gemmation, primary, secondary, and multifold, until the chain is broken by a sexual act of generation, and the being perishes in the production of its offspring.

The resuscitation of Infusoria, after apparent death, forms a chapter in Ehrenberg's great work; but the facts discussed have little or no bearing on this group of Ciliata; and the marvel formerly attaching to the subject is much diminished by our knowledge of the phenomena of encysting, whether for the purpose simply of self-preservation or the carrying out of the process of development.

Influence of External Agents. Heat and Cold.—The Ciliata can support very considerable variations of temperature. Even in winter, beneath the ice, various species may be found still living. Ehrenberg tells us that *Vorticella microstoma* will live after being exposed to a temperature of 8° Fahr., and the ice gradually thawed; in fact, however, not more than one in a hundred will survive this process. Below this temperature none can live. The same is true of *Paramecium Aurelia, Cyclidium Glaucoma, Glaucoma scintillans,* and *Colpoda Cucullus.* When death is caused by cold, no rupture or injury of the body is perceptible, except in the case of *Chilodon Cucullulus* and some few other species, which are frequently quite disintegrated and dispersed. *Stentor polymorphus* and *S. Mülleri* will not live many hours at a temperature of 9° Fahr.; and arborescent *Vorticella,* subjected to the same degree of cold, fall from their stems and die.

Perty gives a list of about 40 species of Ciliata which he found in Switzerland during the cold of winter, beneath the ice; we name a few as a guide to investigators:—*Coleps hirtus* (often without a shell), *C. inermis; Oxytricha pellionella, O. caudata, O. prisca, O. gibba; Pleuronema crassa; Euplotes striatus; Vorticella patellina; Stentor Rösellii; Paramecium Colpoda, P. versutum, P. leucas; Trachelius Anas, T. Lamella, T. Meleagris; Trachelocerca Olor; Glaucoma scintillans; Lacrymaria rugosa; Enchelys Farcimen; Chilodon Cucullulus; Spirostomum ambiguum; Amphileptus Fasciola,* &c.

Ehrenberg affirms that when animalcules are frozen in ice, they are as it were lodged in a little cavity, and surrounded by water. This circumstance he imagined to be due to their animal heat,—an explanation too improbable to be admissible; and, if the observation be correct, it must give place to some other.

Respecting the effects of cold, it is a general law of the Ciliata, that their numbers rapidly diminish when winter sets in, and that, on the contrary, they rapidly augment so soon as the warmth of the sun in spring manifests itself, and continue to increase in number and variety until the height of summer is passed.

Their endurance of heat is almost equally extraordinary as that of cold. Some are found in hot springs: thus Perty found specimens in the hot springs of Leuk, at a temperature of about 80°; and Ehrenberg heated water gradually to 120° Fahr., when *Colpoda Cucullus* and *Chilodon Cucullulus* survived.

NECESSITY OF AIR.—The water which Ciliata inhabit must be duly aërated to support their existence, as is shown by the experiment of pouring a layer of oil on the top of a vessel of water containing them, and by their disappearance from a bottle which has been kept too long corked.

They decrease in number and variety after water has been kept for some time in the house, even though it remains sweet; this is probably due in part to the more stagnant atmosphere and the consequent diminished admixture of air with the water.

CHEMICAL AGENTS. ELECTRICITY AND GALVANISM.—For chemical substances to act, they must be soluble in the water. Sea-water is generally more or less speedily fatal to fresh-water species; and, on the other hand, fresh water is destructive to marine species, especially when the change of medium is sudden. However, some species are common both in sea- and in spring-water; and there are others living in brackish water which can readily accommodate themselves to a change of habitation.

There are also substances, such as sugar, which, although not in themselves poisonous, are damaging to animalcules, probably by causing an injurious alteration in the density of the water. Other substances, having active properties as poisons to animal life at large, such as corrosive sublimate, strychnine, arsenic, and the like, are also poisonous to animalcules. Reference has been made to several chemical compounds which, by reacting variously on the tissues of animalcules, are employed for the purpose of demonstrating points in their organization: such are acetic acid, alcohol, tincture of iodine, solution of potassa, &c. The last acts as a solvent, causing diffluence, as Mr. Addison pointed out some years since (*A. N. H.* 1843, xii. p. 101).

Of the effects of electricity, galvanism, and magnetism, we know little: experiments with these forces are few and imperfect. Ehrenberg collected the accounts of several, among which are the following:—A shock from a Leyden-jar charged with twenty sparks from an electrophorus having a resinous plate $7\frac{1}{2}$ inches square, and a collector $5\frac{1}{2}$ inches, suddenly killed *Stentor niger*, *St. aureus*, and *Amphileptus moniliger*. The bodies of *Ophryoglena atra* and *Stentor polymorphus* were entirely dissipated by it, as were also those of *Epistylis flavicans*, after having first been thrown from their stalks. It generally required two such shocks to kill the *Paramecium Aurelia*. When the electrical current passed near and not through them, their movements appeared unsteady. Electricity slowly produced has a more powerful effect than in the form of rapid shocks; and when either it or the magnetic current decomposes the water in which the animalcules are, then death is a necessary consequence.

Mr. Rood (*Sill. Journ.* 1853, xv. p. 71) has experimented more recently, and states that, when a feeble galvanic current is passed through water containing *Paramecia*, the animals are brought to a stand-still, particularly in the neighbourhood of the negative pole, and after revolving for a time on their own centres, entirely cease to move; ciliary action is also arrested, and diffluence quickly ensues.

On the subject of the operation of chemical reagents on Protozoa, or, strictly speaking, on *Paramecia*, with which he chiefly experimented, Mr. Rood has the following remarks:—Alcohol stopped their motion, coagulated their contents so that they shrunk within their integument, and caused speedy death. Phosphate of soda killed in a few minutes; and Epsom salts, the ammonio-chloride of mercury, acetate of lead, and perchloride of mercury destroyed life instantly. Cyanide of potassium did the same, producing at the same moment rupture of the integument and the discharge of the contents. On adding a quantity of oxalate of ammonia to the water, a stupefying effect at once follows, but after a few minutes the animalcules revive, and death does not result—at least, not for some hours. Likewise, neither ferrocyanide of potassium nor neutral chromate of potash kills—at least, not under several hours. This last-named fact suggests the possibility of chemically injecting or impregnating animalcules, whilst still living, with a mixture of suitable reagents to produce coloured precipitates which might serve in demonstrating their internal structure.

Geographical Distribution.—We know as yet of no special laws of *geographical distribution* of the Ciliated Protozoa; and a long time must, we fear, elapse ere the waters of the earth are sufficiently explored to warrant even an approximative sketch of such laws. Wherever on this globe we may seek for these animalcules, they are, it seems, to be found—even the same families, genera, and species; and if our present knowledge leads us to define particular localities for particular species, it amounts to little more than stating that they have there arrested the attention of some observer or observers, and have been overlooked or searched for at the wrong season, or under unfavourable circumstances, in other places. For, as our remarks on the succession of species imply, the animalcules present in any collection of water one week, may be in vain searched for the next; and the inhabitants of a pool or stream of one season, or of one year, may be exchanged for others the next. Although, therefore, laws of geographical distribution are wanting, yet we may be very much guided in our search for particular genera and species by a knowledge of their habitats and of the conditions which prove most favourable to their existence.

Since the whole framework of Ciliata is sooner or later destructible by diffluence, their occurrence in a fossil condition is not to be looked for.

Affinities of the Ciliated Protozoa with other Animals.—Regarding as we do the organization of Ciliated Protozoa as belonging to a type *sui generis*, their affinities with other animals partake rather of a general than of a particular character. They possess an affinity with *Rhizopoda*, *Gregarinida*, and *Spongilla*, with *Opalinæa*, Polypes, and with many Phytozoa, such as *Euglenæ*, in the nature of their contractile substances or sarcode; also with the first and last-named, in the presence of one or more contractile vesicles. Multiplication by fission is also common to those several tribes, and that by gemmation to *Vorticellina*, *Ophrydina*, and Polypes; lastly, they agree with the Rhizopoda and Polycystina in the process of dissolution by diffluence. In the process of encysting, also, they are related with the *Opalinæa* and Phytozoa, with some, at least, of the Rhizopoda, and, in general characters, with the *Gregarinida*.

Of the mutual relations between the Ciliata (*Opalinæa*, *Gregarinida*) and Rhizopoda, we shall have further occasion to speak. But the Ciliata are also allied to the Rotifera by the *chitinous* constitution of their integument, by being moved chiefly by cilia, and more closely so through certain families, *e. g.* the *Vorticellina* and *Ophrydina*, which have a frontal ciliary mechanism approaching in structure that of the rotary apparatus. So, again, in some general features, the sheathed *Ophrydina* (e. g. *Vaginicola*) may be assimilated with the encased Rotatoria, such as *Œcistes* and *Conochilus*. Lastly, by means of the *Ichthydina* an additional link is established between these two classes, and also between them and the *Turbellaria*; for some, as Schultze (Müller's *Archiv*, 1853, p. 241), seem disposed to range the *Ichthydina* with the last-named family. A homology may be perceived between the hardened integument, with its uncini, styles, and setæ, in such forms as *Coleps* and *Euplotes*, and the covering and appendages of Entomostraca and of some inferior Annelida; and some would note the similarity in movements between *Coleps* and *Daphnia*.

Through the *Vorticellina* a relation is established with the Bryozoa or cilio-brachiate Polypes—one, indeed, which some naturalists (Agassiz, for instance) affirm to be so intimate, that the two families should be placed together in the same group.

Lastly, there is, in the case of many Ciliata, a very close apparent affinity, almost amounting to identity (at least, so far as form is concerned) between them and certain embryonic stages of other animals,—for example, of *Planariæ* and of several of the lowest among the Vermes. It is possible, indeed, that some of the presumed independent Ciliata are nought else but larval conditions; but unless this can be shown by direct observation of their development and transformation, they must be still retained in their present place. The group represented by *Bursaria* and *Paramecium* are, as Agassiz (*A. N. H.* 1850, vol. vi. p. 156) asserts he has satisfied himself by direct investigation, no other than germs of fresh-water worms, "some of which," he writes, "I have seen hatched from eggs of *Planaria* laid under my eyes." To this assertion Mr. Girard assents (*Proceedings of American Association*, 1848, p. 402). However, there is one caution to be borne in mind in seeking to establish the unity of certain supposed specific forms and known embryonic phases of any animals—viz. not to confound general resemblance with specific identity. For, notwithstanding the former may be very distinct and close, this is not enough (as the history of development of the higher animals teaches us) while there is aught wanting in the image, to render it an exact counterpart of the original, identical in kind with it.

The above offers a general sketch of the most evident affinities of the Ciliata. By the exercise of the imagination directed simply to external form, these might be greatly multiplied: this, however, would, instead of advancing our knowledge, lead only to misconceptions.

Classification of the Ciliated Protozoa.—Among the many heterogeneous groups of beings which have at a previous period been assembled under the name of Infusoria, or other terms tantamount to it, that of the ciliated animalcules has been more or less clearly distinguished from the rest, and has received much attention from the several propounders of schemes of classification. However, as our knowledge of the Ciliata, both with respect to the number of known species and to their minute organization, on which alone any correct classification can be based, has been so greatly extended during the last few years, it would be useless to describe the various systems which were suggested when, as we may say, this branch of natural history was in its infancy.

We shall therefore omit all notice of any systematic arrangement of the Ciliata prior to that proposed by Ehrenberg. Now, although this arrangement is very imperfect and incorrect, and founded, moreover, upon certain views of their organization now generally rejected, yet, as it was the system adopted in previous editions of this work, and will be generally followed in the present one; and as, moreover, no other classification can lay claim to such completeness and accuracy as to command its adoption instead, it behoves us to detail its principal features. Besides this distribution of Ciliata, suggested by the great micrographer of Berlin, there are three others it will be necessary to describe in this place, severally proposed by Dujardin, Siebold, and Perty. Of these, however, it will only be necessary to present the outline as given by their respective authors, since the examination of the characters, limits, and mutual relations of the families described will form the subject of the Systematic portion of this work.

The Ciliata, in our meaning, are very nearly the same beings that Ehrenberg called *Enterodela*, or *Polygastrica* furnished with an intestine connecting together their stomach-sacs. A division of the Enterodela was made, according to the mutual relation in position between the two orifices of the body—the mouth, and anus or discharging vent—into, 1st, *Anopisthia*, in which the intestine is so curved on itself that its two ends unite together in a common aperture; 2, *Enantiotreta*, having an oral opening at one extremity, and the anal at the other, *i. e.* opposite to each other; 3, *Allotreta*, with the two orifices placed obliquely with reference to one another; and 4, *Catotreta*, with both situated on one surface—the abdominal. The subjoined tabular view will display these divisions, and also their subdivision into families.

We have departed from this arrangement of Ehrenberg chiefly by omitting a few genera and species, viz. *Actinophrys*, *Trichodiscus*, and *Podophrya* among the *Enchelia*, and some species of *Bursaria* from the *Trachelina*, and also by adding several new genera and families. Concerning the necessity of detaching the *Actinophrys* and its two congeners from the *Enchelia*, no doubt can be entertained when their structure comes to be considered; we have thrown them together into one family under the name of *Actinophryina* (p. 243), and have brought them and the peculiar beings known as *Acinetina* (p. 258) together as two subdivisions of Rhizopoda. The peculiar parasitic *Bursariæ* without mouth constitute, with some similar ciliated mouthless beings, a subdivision of the Ciliata, standing in near relation with *Gregarinida*, and, in some measure, intermediate between the Ciliata and Rhizopoda. Lastly, we have removed the *Ichthydina* from the Rotatoria, and treated them as a subclass of Ciliata. The additional families and genera we shall not here specify, but must direct the reader for information to the systematic descriptions.

The following tabular view represents Ehrenberg's classification.

	SECTIONS.			FAMILIES.
Enterodela, with an alimentary canal.	One receiving and discharging orifice only for nutrition. *Anopisthia.*	illoricated		Vorticellina.
		loricated		Ophrydina.
	Two orifices: one at each extremity. *Enantiotreta.*	illoricated		Enchelia.
		loricated		Colepina.
	Orifices situated obliquely. *Allotreta.*	illoricated	mouth furnished with proboscis, tail absent	Trachelina.
			mouth anterior, tail present	Ophryocercina.
		loricated		Aspidiscina.
	Orifices abdominal. *Catotreta.*	illoricated	locomotive organs, cilia	Kolpodea.
			——— various	Oxytrichina.
		loricated		Euplota.

Dujardin's distribution next claims attention. Having, as we have seen, entirely rejected Ehrenberg's polygastric hypothesis, and at the same time failed to recognize many important points of internal organization now well established, he had, to construct his system, recourse to external characters only—to the presence or absence of locomotive organs, to the characters of those organs, to the nature of the external surface, whether protected by an integument or not, or defended by a lorica, to the general conditions of attachment of fixed forms to other objects, and to the character of their movements when free. Moreover, his Ciliated Infusoria comprised not only our group of Ciliated Protozoa, but also the Phytozoa,—the *Vibrionia* only excepted; for he made no distinction between organisms moved by a single or few filaments, and those moved by vibratile cilia generally distributed, or associated together in the construction of special locomotive organs.

In his tabular view, the beings we have brought together under the appellation of Ciliata are all comprehended in the fourth and fifth orders of Infusoria, with the exception of *Coleps* and the *Ichthydina*, which, in his opinion, belong to a type of structure differing from all others reckoned by him as Infusoria, in being symmetrical.

The accompanying outline of this system of Dujardin will sufficiently illustrate it at present, without further remarks on the value either of the principles he has adopted, or of the families and genera he has instituted.

DUJARDIN'S CLASSIFICATION OF CILIATA.

Order IV.—Ciliated animalcules without a contractile integument. All swimmers.

A. NAKED.

Fam. 11. Enchélyens, without mouth; cilia disposed without order.

12. Trichodiens, with the mouth either visible or indicated by a fringe of cilia, without cirrhi.

13. Kéroniens, with a mouth and a fringe of cilia, together with some cirrhi or strong cilia in the form of styles or uncini.

B. LORICATED.

Fam. 14. Plœsconiens. Lorica or shield diffluent or decomposable like the rest of the body.

15. Erviliens. Lorica genuine and persistent. A short pedicle.

Order V.—Ciliated animalcules provided with a lax, reticulated, and contractile integument; or having their cilia so arranged in regular linear series as to denote the presence of an integument.

A. ALWAYS FREE.

Fam. 16. Leucophryens, without a mouth.

17. Paraméciens, with a mouth but no prominent row of cilia.

18. Bursariens, with a mouth and a prominent row of cilia.

B.—EITHER VOLUNTARILY ATTACHED OR FIXED BY THE MEDIUM OF ORGANS.

Fam. 19. Urcéolariens, voluntarily attached.

20. Vorticelliens, attached at least temporarily either by their organs or by some part of their body.

SYMMETRICAL INFUSORIA.—Of several types without mutual relations.
Planariola. Coleps. Chætonotus. Ichthydium.

With the exception of the family *Leucophryens*, which is nearly equivalent to our subgroup *Opalinæa*, and of the genera *Planariola*, *Chætonotus*, and *Ichthydium* (the two last constitute our family *Ichthydina*), all the other families and genera are members of our class of Ciliata, and are described in the Systematic portion of this work.

Prof. Siebold (*Anatomie der Wirbellosen Thiere*) agreed with Dujardin in rejecting the Polygastrica of Ehrenberg as a class, and at the same time employed the term Infusoria, applied after Ehrenberg's example to a multitude of various organisms both animal and vegetable, to designate a comparatively limited group. To this restricted use of the term we have already objected (p. 199); we will now, therefore, proceed with the classification in question. Siebold's Infusoria included all those microscopic organisms, exclusive of the Rhizopoda, of supposed animal nature, whether possessing a mouth or not. Of these he made two classes: one named *Astoma*, the other *Stomatoda*, the latter equivalent to our Ciliata. The following tabular outline is presented by Siebold, without any comments on the characters and distinctions of the several families, which, however, agree in general with those instituted by Ehrenberg, the most striking departure being the exclusion of *Ophryocercina* and *Aspidiscina.*

SIEBOLD'S CLASSIFICATION OF CILIATA.

CLASS I.—INFUSORIA, Animals moving by cilia.

Order 1.—ASTOMA, Infusoria without a mouth.

Fam. 1. ASTASIÆA.—*Gen.* Amblyophis, Euglena, Chlorogonium.
Fam. 2. PERIDINIÆA.—*Gen.* Peridinium, Glenodinium.
Fam. 3. OPALINÆA.—*Gen.* Opalina.

Order 2.—STOMATODA, Infusoria with a mouth.

Fam. 1. VORTICELLINA.—*Gen.* Stentor, Trichodina, Vorticella, Epistylis, Carchesium.
Fam. 2. OPHRYDINA.—*Gen.* Vaginicola, Cothurnia.
Fam. 3. ENCHELIA.—*Gen.* Actinophrys, Leucophrys, Prorodon.
Fam. 4. TRACHELINA.—*Gen.* Glaucoma, Spirostomum, Trachelius, Loxodes, Chilodon, Phialina, Bursaria, Nassula.
Fam. 5. KOLPODEA.—*Gen.* Kolpoda, Paramecium, Amphileptus.
Fam. 6. OXYTRICHINA.—*Gen.* Oxytricha, Stylonychia.
Fam. 7. EUPLOTA.—*Gen.* Euplotes, Himantophorus, Chlamidodon.

Perty is the latest writer, as far as we can discover, who has attempted a classification of Infusoria, among which he distinguishes, as we do, a class under the name of Ciliata, having also in almost all respects similar limits, except in the retention of the *Actinophryina* as one of the two sections he makes, viz., 1, animalcules with vibratile cilia; and 2, with non-vibrating but slightly contractile cilia, or filaments. Leaving this second section out of view, the other is divided into three subsections, with the titles *Spastica, Monima,* and *Metabolica,* according to the varying character of their movements, which in the first are sudden and jerking, in the second, unvarying and constant, and in the third, associated with striking changes in the figure of the body. Under these three subsections he distributes all the Ciliata into families, to many of which, in departing from Ehrenberg's groupings, he has given new names. He moreover describes many new genera and species. Besides the *Actinophryina,* we exclude also the family *Cobalina,* which is equal to our family *Opalinæa,* and to Dujardin's *Leucophryens.*

We shall attempt to represent this system of classification by a tabular outline:—

PERTY'S CLASSIFICATION OF CILIATA.

A. SPASTICA.—*Animalcules capable of contracting their bodies and their stems, when such exist, in a sudden spasmodic manner, so that their more or less elongated figure is rendered oval or globular, and the stem coiled spirally. They are the only Ciliata which live associated, and are related to Bryozoa, and many to Rotatoria.*

Fam. 1. VAGINIFERA.—Enclosed in a sheath, into which they can withdraw themselves. Mouth with a ciliary wreath.
Fam. 2. VORTICELLINA.—Without a sheath; living isolately, or in arborescent polyparies; with a contractile body and evident mouth, but no intestine. Developed by fission, by germs, and gemmation, and by means of transitional phases.
Fam. 3. OPHRYDINA.—Numerous animalcules associated together in a solid gelatinous mass, but without contractile fibres.
Fam. 4. URCEOLARINA.—The Urcéolariens of Dujardin, *Ophrydium* being excluded, and *Spirostomum* added.

B. MONIMA.—*Animalcules which, although very contractile, neither undergo change of form nor exhibit jerking movements.*

A. *General covering soft.*—1. *Free forms, with a mouth; nutriment received solid.*

Fam. 5. BURSARINA.
Fam. 6. PARAMECINA.—Body covered by longitudinal rows of cilia. Mouth lateral, often situated in a furrow.
Fam. 7. HOLOPHRYINA.—Mouth anterior; anus posterior. Cilia in longitudinal rows.

Fam. 8. APHTHONIA.—Surface ciliated, and furnished besides with filaments.
Fam. 9. DECTERIA.—Mouth provided with a circlet of bristles; in three genera lateral, in two anterior in position.
Fam. 10. CINETOCHILINA.—Mouth on the upper surface, furnished with a vibrating flap. Cilia in longitudinal lines.
Fam. 11. APIONIDINA (in part the Enchelia, *Ehr.*, and the Paraméciens, *Duj.*).—Bodies small, soft, thicker at one end than the other; cilia in longitudinal rows. Mouth, where perceptible, at the anterior extremity.
Fam. 12. TAPINIA.—Cilia scattered, or collected in particular spots, but never in rows. Body usually very small. Mouth only proved to exist by means of artificial feeding.
Fam. 13. TRACHELINA.—Body elongated into a neck-like anterior process, or a laterally curved trunk.
Fam. 14. OXYTRICHINA.—Equal the Kéroniens of Dujardin.

2. *Parasitical forms, with or without a mouth, mostly receiving only the juices of other animals.*

Fam. 15. COBALINA.—Body mostly flattened, oval, elliptic or reniform, covered by numerous rows of fine cilia, and oftentimes with jointed cilia on the under surface. A raised margin or hollow fold occupied by cilia often indicates the mouth, of which, however, in several cases, no trace is evident. The animalcules commonly live internally, upon the juices of other beings, and occasionally on their outer surface, in which case the food they take is solid. They present among themselves numerous peculiarities and points of agreement, and at the same time many anomalies, and are lower in the scale than free living forms similar to them, *e.g.* Oxytrichina; their movements are rather automatic. The genera included are, *Alastor* (*Kerona*, Ehr.), *Plagiotoma*, *Leucophrys*, and *Opalina*.

B. *General covering firm by induration of the integument, or by excretion of hard granules.*

Fam. 16. EUPLOTINA.—Equal the Plœsconiens of Dujardin.
Fam. 17. COLEPINA.—Represented by the genus *Coleps* (Ehr.).

C. METABOLICA.—*Very contractile; undergoing protean alterations of their figure through a contraction and extension of the body. Cilia scarcely observable on the body at large, but collected on the neck-like process.*

Fam. 18. OPHRYOCERCINA (Ehr.), including also Trachelocerca and Phialina.

FAMILY I.—ICHTHYDINA.

(Plates XXV. 357, 358. Plate XXXI. 28, 29, 31.)

This family, which in our arrangement forms a subgroup of Ciliata, constituted in Ehrenberg's system a section of Rotatoria,—an association which cannot be maintained now that their more intimate and essential organization is known. Indeed, these beings seem to have received but little attention from that great naturalist, who had only an imperfect account of them to offer. They were described as Rotatoria with a single continuous rotary organ, not cut or lobed at the margin, and without lorica or shell. Four genera were enumerated—viz. *Ptygura*, *Ichthydium*, *Chætonotus*, and *Glenophora*. Their relative peculiarities were thus stated:—*Ptygura* and *Glenophora* had a simple rotary locomotive organ; *Ichthydium* and *Chætonotus*, only a long ciliary band upon the ventral surface. Again, the two former had a simple foot-like process, and evident œsophageal teeth; the two latter a forked tail and no visible teeth. Dujardin, who has given a very good account of *Chætonotus*, rejected that genus, together with *Ichthydium*, from among the Rotatoria, and placed the two in a sort of subfamily of Ciliated Protozoa, under the name of 'Symmetrical Infusoria.' Of the other two genera, *Glenophora* and *Ptygura*, he ignored altogether the former, and transposed the latter to his family of '*Melicertiens*.' Since the date of his systematic treatise (*Hist. des Infus.* 1841), he has sketched the history of a genus under the name of *Ellimoderia*, which is evidently allied to *Chætonotus* (*A. S. N.* xv. p. 158).

The latest researches, we have seen, on the *Ichthydina* are contained in a paper by Dr. Max. Schultze (*Müll. Archiv*, 1853, p. 241), on *Chætonotus* and *Ichthydium*, and on a new allied genus, *Turbanella*. In this communication Schultze clearly shows that *Chætonotus* and *Ichthydium* are not Rotatoria, whilst he admits *Ptygura* and *Glenophora* to be so. The leading and sufficient reasons for separating *Ichthydium* and *Chætonotus* from Rotatoria are, that they want the peculiar ciliary apparatus of that class have no retractile rotary disk, no jointed tail-like process, no water-vascular system with vibratile tags, and no perceptible muscular and nervous system. The best account of the organization we have of any of the *Ichthydina* is furnished by Schultze's contribution above quoted, wherein he details that of *Turbanella*. Of this we will present an abstract, but, before so doing, will preface a few notes from Dujardin on *Chætonotus*. This genus has a symmetrical elongated-oblong body slightly contracted at its anterior third, and having its posterior half expanded; covered on its upper or posterior surface by cilia or by ciliated scales; terminated anteriorly by a rounded edge, near to which is a distinct circular oral aperture; and posteriorly ending by a bifurcate process. Some long vibratile cilia are visible on the anterior half of the ventral surface; and Dujardin thought he discovered four or five minute papillæ around the mouth. This aperture he represents to lead into a long narrow œsophagus, which abruptly ends in a wide intestine, that continues a straight course to the posterior extremity, where an anal opening is probably placed. The *Turbanella hyalina*, of Schultze, has an elongated, rather compressed, colourless body, from $\frac{1}{60}$th to $\frac{1}{40}$th of an inch long, and $\frac{1}{180}$th to $\frac{1}{300}$th broad. The head is separated from the body by a constriction (XXXI. 28). Along the body, at apparently regular distances, numerous bristle-like processes stand out at right angles on each side. The posterior extremity is slightly contracted, and divided into two comb-like flattened processes or lamellæ, having an intervening fossa, into which the anal aperture opens. A dorsal and ventral surface are distinguishable,—the latter ciliated throughout, the former bare. The head is entirely covered on its upper surface by fine cilia, besides which, it has a circlet of larger ones around its middle. The ciliated condition of the under surface is displayed by a side or a transverse view of the animal. The bristle-like processes on each side are growths from the integument, and neither articulated nor separable (XXXI. 28, 30). The row is double on either side; the under setæ from 20 to 25 in number; the upper, only from 6 to 8 on a side. The latter are rather appendages of the dorsal surface, and are, moreover, not at right angles like the others, but bent backward. Each cutaneous process is terminated by a motionless cilium, equal to or exceeding it in length. The cuticle and its processes are soluble in a warm solution of potash, and are not chitinous.

The alimentary canal passes straight through the middle of the body (XXX. 28, 29). The mouth, situated at the anterior extremity, is circular, and surrounded by a finely plicate or dentate margin; it opens into a muscular œsophagus, which very much resembles that of *Anguillula*, and terminates below in the straight intestine. The œsophagus extends for the first fourth of the length of the body; and its muscular coat is so developed, that its canal looks like a mere central line. Its muscles are annular. The tubular intestine has, on the contrary, thin walls, in which numerous molecules and fat-corpuscles are distinguishable, except, indeed, at its posterior conical termination. The intestine lies in a soft, finely-granular parenchyma. No water-vascular apparatus with vibratile tags exists. At the posterior third of the body, on the dorsal surface of the intestine, a large ovary is placed, and in front of it a very much smaller testis. Both glands present a mulberry-like aggregation of rounded cells. The posterior portion of the ovary exhibits ova, having a germinal vesicle and spot surrounded by a fine granular yelk-mass; and one or two ova are frequently seen separated, having a delicate colourless shell developed around them. The diameter of the largest ova equals $\frac{1}{480}$th. The mature eggs lie close to the testes. Besides this distinct male organ, two groups of *spermatozoid*-cells seem present, lying apparently free in the loose parenchyma, and apparently without any investing membrane or envelope. As to their affinity, Schultze makes no doubt that they are Vermes, and belong to the group of Turbellaria, considered as a division of the Cestoidea. Among Turbellaria they are best placed with the Arhynchia, including *Microstomum* and *Dinophilus*. They resemble *Nematoidea* and *Anguillulæ* in the form of the intestinal canal, but are unlike these in their figure, their ciliated integument, and their hermaphrodite structure.

The *Ichthydina* are inhabitants of fresh water, living among aquatic plants. They have a sluggish, creeping gliding movement, resembling that of most Turbellaria.

FAMILY II.—NOCTILUCIDA.

(Plate XXXI. 32–39).

This small but remarkable subsection is represented by only one animal, the *Noctiluca miliaris*, which has attracted much attention as one of the sources of the phosphorescence of the sea. By several recent authors it has been treated as a near ally of the Ciliata, although it must be confessed to have few outward indications of such a relationship, and, in our estimation, is a representative of quite a different and independent group of animals. At first sight, a *Noctiluca* appears a round gelatinous corpuscle having a depression or groove at one part, surmounted by a filamentary process or tentacle. Compared with the Ciliated Protozoa, it is of gigantic proportions, attaining $\frac{1}{30}$th of an inch in diameter. On closer examination it is found to have an integument of two layers: the outer smooth and reticular, structureless, and of considerable density; the inner a delicate, granular, gelatinous membrane, which Dr. Webb (*J. M. S.* 1855, p. 103) describes to be in union at all points with the whole system of reticulations spreading from the central organs,—a fact rendered evident by the action of indigo and the primary changes consequent on death. "The internal fibrous reticulations gradually contracted, drawing the 'vacuoles' together, and with them the inner membrane. This was detached without rupture, but after a time fell into folds, which so included the other structures as to have the look of a wrinkled tube with a series of pouches ending in a larger membranous sac. The external layer distended by degrees till it suddenly burst. I should mention that a new supply of water had been given before most of these changes happened. I have also been successful in separating the two layers mechanically, by means of pressure, slowly and steadily applied to the animal under the screw compressor." The external membrane is extended at one point into a tapering process, which acts as a locomotive organ. It springs from the edge of the infundibulum, which is extended backwards into a pharynx or gullet. This process or tentacle appears transversely striped, and breaks short; of the nature of those stripes we know nothing. Dr. Webb believes this process to be tubular, with an orifice on the inner side at its base. "At any rate," he writes, "I have seen the colour, when iodine has been used, proceed towards the distal extremity; and under the influence of indigo poisoning, the granular matter of which the striation consists has been disarranged, scattered up and down the interior of the organ, and in the end has aggregated together in small globules, without much impairing the power of motion." These appearances do not at all convince us of the tubular character of the tentacle; for they are attributable to the difference of action of the chemical reagents upon the contained matter and upon its investment. Dr. Webb adds—"I have never perceived any tendency to restoration of the lost part, nor any independent movement in the detached fragment. The stump continues active, and readily comes off at the base. The point is a little flattened. When the animal is killed in such a manner that this organ has free play, it always shows a disposition to coil up spirally."

Prof. Huxley's comparison of the *Noctiluca*, in figure, to a peach is very good, and conveys a clear idea of the relative position of the external groove and its appendages (*J. M. S.* 1854, p. 50). "One surface," he writes, "is a little excavated; and a groove or depression runs from one side of the excavation, halfway to the other pole. Where the stalk of the peach might be, a filiform tentacle, equal in length to about the diameter of the body, depends from it, and exhibits slow wavy motions when the creature is in full activity. I have even seen a *Noctiluca* appear to push repeatedly against obstacles with this tentacle." Behind the tentacle is a rounded or oval mouth, having a harder margin extending from the base of the tentacle, along its right side, in the form of an elevated ridge. This ridge has a horny appearance (although Dr. Webb declares it to be of fibrous consistence), and is usually described as sigmoid in outline. About its middle is a triple (tricuspid) tooth-like elevation, composed of a middle, bifid, large portion, and a smaller one on each side. Dr. Webb says that when this tooth is "seen in profile, it has the appearance of a conical papilla, or, with a slight change in the point of view, of a hooked process terminating in a sharp nib. It readily yields to pressure; and I have seen it become shrivelled up from the use of astringents, before motion ceased in the cilium and tentacle....The ridge may be sometimes observed in regular contractile action. Corresponding with these contractions, I have witnessed a to-and-fro motion of the tooth, as though working on an axis in a direction towards the base of the tentacle. A good illustration of this performance is given by bending the fore and middle fingers, and flexing them on the palm of the hand." On the other hand, Prof. Huxley states that he never observed any movement in this tooth-like body.

The oral aperture opens into a funnel-like cavity or pharynx, from the bottom of which a ciliary process extends, having a rapid undulatory movement, and retractile. Mr. Huxley only now and then detected this cilium, and states that it is difficult of observation; but Dr. Webb says—"The cilium may be found in every instance in which it is looked for with a quarter-inch glass, or even with the half-inch, provided the creature is left at perfect liberty, and is made to move if not in the right position. It often remains at rest for some time, and then from above looks like a small bright spot at the base of the 'tooth;' or it may occasionally be seen extended over the S-shaped ridge, or even the base of the tentacle. I have many times detected it in motion from behind, through the intervening substance of the body, and have noticed it vibrating vigorously long after rupture of the integument and partial discharge of the contents. A Chara-trough, or shallow concave cell, is most convenient for observations on this part, as the animal swims close to the under surface of the thin glass, and may be made to turn in any direction."

A minute oval aperture is represented both by Huxley and Webb as opening into the funnel-shaped oral cavity. This last expands into an alimentary space "of very various form and dimensions, capable of great dilatation, and presenting no distinct walls, but rather excavated in the central substance of the body, which is connected with the parietes by numerous granular radiating filaments" (*Huxley's Lectures, Medical Times*, 1856, vol. xxxiii. p. 511). These granular filaments radiate, from a central portion which seems to serve as a bond of union and a basis of support for all the organs about the oral cavity, to the integument in every direction; and probably the apparent reticulation of the external membrane is due to the crossing of the very fine terminations of those filaments as they proceed to attach themselves to it. Lying amid the meshes of this fibrous network, chiefly towards the centre of the *Noctiluca*, are more or fewer vacuolar bodies. "The whole internal network of fibrous tissue," writes Dr. Webb (*op. cit.* p. 104), "with the manner in which it invests the so-called vacuoles, is most beautifully demonstrated by the effect of iodine. The creature dies suddenly, without collapsing. The progress of the fluid can be traced along the fibres into the minutest meshes; and there remains for a long time a transparent ball, traversed in every direction by the brown fibres, headed with the vacuoles and granules, and having every reticulation on the surface sharply defined."

The "vacuoles" referred to are not homologous with those of Protozoa, and, to avoid confusion, another name should be found for them. They are actual sacs or cells, with a definite membranous wall, and thus appear to resemble in structure the contractile sacs of Protozoa. Dr. Webb asserts them to be alimentary sacs; and we gather from him the following account of them (*op. cit.* p. 105):—"When empty, they are usually contracted and grouped near the membranous tube which leads from the oral aperture—a few only being scattered among the internal reticulations. Their situation is constantly changing, sometimes with a steady advance, at others by jerks, while the fibrous meshes with which they are connected undergo a relative alteration in shape. Gentle pressure will occasionally expel them through the oral or anal aperture; but I have seen them spontaneously ejected without rupture, and float away from the body. In one instance where this occurred, and where the contents consisted of granular matter, fragments of *Diatomaceæ*, and particles of sand, the sac remained entire for some time. When it burst, the membrane doubled up, the contents escaped, and the bits of silica were characteristically shown with the polariscope. I have never known these gastric pouches, or alimentary substances to be voided by any other outlet than those connected with the central depression."

At the bottom of the infundibulum is a large-sized oval, or ovoid, brownish body, of granular consistence, and strongly refracting light, which is the nucleus. It lies in front of and above the gastric cavity, and, Prof. Huxley states (*op. cit.* p. 54), assumes the appearance of a hollow vesicle when acted upon by acetic acid. Dr. Webb writes (*op. cit.* p. 106)—"The nucleus may be demonstrated as a nucleated vesicle, sometimes solitary, more frequently with several similar but smaller nucleated vesicles grouped around it. By careful manipulation it may be removed from the other structures; and as it floats about, its true form is displayed. Seen in one position, you have a view of a round vesicle with a smaller vesicle attached to it by a sort of hour-glass contraction; in another, of a round vesicle with a central spot, a nucleated cell. I have found the nucleus enclosed in a second membranous envelope with a granular yelk-like fluid, which could be seen pouring out when the membrane gave way."

The reproduction of the *Noctilucida* is as yet not understood. Quatrefages and Krohn, Prof. Huxley informs us (*op. cit.* p. 54), "consider that a process of fissiparous multiplication takes place, and that both of these observers have found double individuals, though very rarely. According to the latter writer, division of the body is preceded by that of the nucleus. I have not had the good fortune to meet with any of these forms; and the only indication of a possible reproductive apparatus, which I have seen, consisted of a number of granular vesicular bodies of about $\frac{1}{2000}$th of an inch in diameter, scattered over the surface of the anterior and inferior part of the body." Dr. Webb (*op. cit.* p. 105) has the following observations on this subject:—"I have never met with a double individual, but on one occasion witnessed the process of division, without, however, noting any proof of its connexion with that of fissiparous multiplication. Contractions of the integument took place in such a way as to cut off a globular mass from the body, about one-fourth of the whole. The two portions afterwards retained their form, with a puckered mark at the point of separation. The nucleus was not involved in this operation, which occupied about two hours.

"It is also a matter of every-day observation, that when the body has been torn and nearly all the contents have been lost, the animal continues to live in a deformed state, if the nucleus and central parts are left together. They acquire a new investment; or a portion of the original integument gathers up round them, while the ragged shreds are cast off.

"When several of these creatures have been kept for some time in still water, it is not unusual to find two of them in apposition; but I have never discovered any indications of conjunction, and look upon the condition as one of mere adhesion. It may, however, have given rise to the mention of double individuals, as the adhesion is tolerably firm. It may easily be broken up without injury to either animal."

In the *Journ. of Micr. Science* for 1855, p. 99, is the translation of a paper by Dr. Busch on the structure and function of *Noctiluca*, in which several original observations are given which appear to bear on this question of development. There is, however, such uncertainty about them, and the want of confirmatory evidence, that we deem it unnecessary to quote them, and must therefore refer our readers to the Journal cited. The fourth volume of the same excellent periodical (p. 74) contains a translation of a paper by Prof. Müller, from which it appears that this distinguished naturalist had discovered *Noctiluca* in an encysted condition. The account he gives stands thus:—"These encysted bodies constituted the principal luminous animalcules observed at Messina in the autumn of 1853. Free *Noctilucæ* at that season were not seen there; and in 1849 the same kind of encysted bodies were very common at Nice. The cyst is a perfectly transparent, spherical capsule, with a light-bluish brilliancy at the edge, and appearing like the egg-membrane of some Crustacea. Within this cyst is lodged a body in all respects resembling the *Noctiluca miliaris*, except that at this time no vibratile filament can be perceived. The *Noctiluca*-like creature fills the cyst more or less entirely, though occasionally it is much smaller. In this condition the animalcules are luminous without being agitated. When the cysts are examined under the microscope in a small quantity of sea-water, in such a way that during the observation the saline contents are notably increased in consequence of the evaporation, a moment speedily arrives when the *Noctiluca*-like body suddenly contracts itself within its case into a little nodule; that is to say, it contracts upon the yellowish granular nucleus from which the filamentary strings of the interior proceed. I have noticed this vital phenomenon, not on one occasion only, but in many of the encysted animalcules.

"The size of the case is usually from $\frac{1}{5}'''$ to $\frac{1}{4}'''$. But many are far smaller, even down to $\frac{1}{10}'''$. Occasionally also, instead of a *Noctiluca*, cysts may be observed, containing a yellow nucleus $\frac{1}{24}'''$ in diameter; and once I noticed a cyst $\frac{2}{10}'''$ in size, containing, besides this rounded yellow nucleus, quite isolated, an extremely minute *Noctiluca*-like body. Of the free *Noctilucæ* taken near Heligoland in the autumn, the smallest were $\frac{1}{20}'''$, and the larger

$\frac{4}{20}'''$ to $\frac{7}{20}'''$ in diameter. The common variety of form, with a constriction of the circumference, which is noticed in free *Noctilucæ*, and the radiating filamentary branching striæ beset with extremely minute granules in the interior, were also characteristic of the encysted bodies, which I should be more indisposed to separate from the *Noctilucæ*, from their possessing the most remarkable luminous power. At present we want the key to these re-remarkable phenomena, as well as all knowledge of the development and course of life of the *Noctilucæ*."

We have, in our prefatory observations on this family, alluded to the opinion of the affinity of *Noctilucida* with Ciliated Protozoa. Prof. Huxley (*op. cit.* p. 54) has the following notes on this subject:—"If the preceding account be correct, it is obvious that the animal is no Rhizopod, but must be promoted from the lowest rank of the Protözoa to the highest. The existence of a dental armature and of a distinct anal aperture, are structural peculiarities which greatly increase the affinity to such forms as *Colpoda* and *Paramecium*, indicated by Krohn. *Noctiluca* might be regarded as a gigantic Infusorium with the grooved body of *Colpoda*, the long process of *Trachelius*, and the dental armature of *Nassula* united in one animal.

"On the other hand, the general absence of cilia over the body, and the wide differences in detail, would require the constitution of at least a distinct family for this singular creature."

To our apprehension there is no homology between the dental armature of *Noctiluca* and of *Nassula*. In the latter, the so-called teeth appear to be nothing more than hardened folds of the membranous tube of the œsophagus, which may disappear by distension,—whilst in *Noctiluca* it is the condensed uncinate margin of the oral cavity on one side which constitutes the dental apparatus. Again, as to the presence of a distinct anal aperture, this certainly establishes no other affinity with the higher Ciliata than it does with any other microscopic animalcules which possess such an outlet. On the contrary, there is force in the particulars mentioned as opposed to their relation with the Ciliata, viz. "the general absence of cilia, and the wide differences in detail;" for cilia either diffused over the body, or collected into groups to form a special ciliary organ, are, when taken in connexion with the peculiar internal organization, so very characteristic that no microscopist, unbiassed by imagination, would reckon *Noctiluca* among Ciliata. In further opposition to the notion of such an affinity, it may be urged that *Noctiluca* is destitute of a ciliated contractile œsophagus, and of a contractile vesicle, that it does not produce vacuoles in the introduction and transmission of food, and that its so-called vacuoles appear to be actual closed sacs, separable from the body. Other distinctive peculiarities between the two might be adduced; but we think that, on reflection and a comparison between them, observers will agree with us that *Noctiluca* is not a member of the Ciliated Protozoa, that it cannot be included among them as a new family, but must be placed in some other class of animalcules, or of itself form the representative of a new class.

The *Noctilucida* are inhabitants of the ocean, of the luminosity of which they seem to be the most potent cause, of the many which have been found in operation. They occur in the British seas, as well as elsewhere, floating on the surface of the water. Mr. Byerly, of Liverpool, noticed their prevalence in such numbers that the water acquired a rose-colour; and Dr. Webb (*op. cit.* p. 102) intimates that their luminosity must depend on some peculiar condition of their organs, or the media acting upon them. This supposition is analogous to that made by Ehrenbérg respecting the phosphorescence of the *Peridinicea*, which he believed to be due to what he termed the "ovaries," or the masses of brownish-red matter which sometimes nearly fill the interior. Perhaps the brown granular matter which at times accumulates in and about the nucleus of *Noctiluca,* and which is probably related to the reproductive function, is the luminous material in this animal; and there is nothing contrary to analogy in supposing the development of phosphorescence to be associated with a particular period of vital activity, but rather everything in its favour. The following valuable note on the collection of specimens occurs in Dr. Webb's excellent paper (*op. cit.* p. 102):—"As a caution to those who may undertake the further examination, I may state that the buoyancy of the *Noctiluca* is such as to bring it to the surface of tranquil water without any apparent effort, and that the best way to effect its capture is, not as is most frequently done, to use the muslin net, by which means the greater number of the creatures are lost or destroyed, but to skim the top, and especially those parts near the sides of the vessel in which the water has been standing. If removed in this way, and kept by themselves in a test-tube, they may be preserved for two or three weeks without a fresh supply of water. Even at the end of that time, if they die, it does not appear to be from having reached the natural term of their existence, but as the result of some accidental cause; they will not, however, bear carriage to any great distance in closed vessels."

We gather the following hints for the capture of *Noctilucida* from a paper by Col. Baddeley (*T. M. S.* 1858, p. 79):—"Attach," he says, "a fine muslin net to the end of a light pole, and proceed to some spot where the *Noctilucida* are likely to be driven. A breakwater which causes an eddy to collect *Medusæ,* &c. generally yields a good harvest. Skim the surface, and wash the net repeatedly in a can of salt water. At night these creatures are easily seen by their luminosity; by day, if plentiful, they cover the surface of the sea in brownish streaks....The best winds in which to capture these creatures appear to be those from south to west; during their prevalence, I have taken *Noctilucæ* every month of the year on the east coast of England; but it is during the summer months they are most abundant, and during calm weather. Abroad, they are constantly to be met with in warm latitudes; and I feel confident some interesting results might be obtained by securing these creatures in various parts of the world." In conclusion he refers to the *Diatomeæ* which are so commonly found in considerable quantities in their interior.

FAMILY III.—DYSTERIA.

(Plate XXXI. Figs. 24–27.)

Dysteria, which is clearly the type of a new family of animalcules, was so named by Prof. Huxley in honour of its discoverer, Mr. Dyster. Although its exact systematic position and affinity are not agreed upon, it certainly occupies a position in the zoological scale above the Ciliata, if it does not rightly take its place, as Mr. Gosse contends, among the Rotatoria.

As we have unfortunately no knowledge, personally, of this interesting being; we must avail ourselves of the excellent description afforded by Prof. Huxley (*J. M. S.* 1857, p. 78), and of the critical examination of its affinities furnished by Mr. Gosse (*ibid.* p. 138).

"*Dysteria armata* has an oval body, $\frac{1}{350}$th to $\frac{1}{250}$th of an inch long, by $\frac{1}{400}$th to $\frac{1}{450}$th broad, which is not altogether symmetrical—the one side presenting a considerable evenly-rounded convexity, while the other, less prominent, is divided by an angulated longitudinal ridge into a smaller, dorsal, and a larger, ventral area. The edges of both lateral surfaces are sharp and thin; dorsally they are separated by a shallow groove; but along the ventral line of the body the groove is deep and narrow, and the produced edges of the lateral parietes resemble the valves of a bivalve shell.

"The ventral and dorsal grooves pass into one another in front; but posteriorly the lateral edges are united for a short space. The edge of the left, less convex, side of the body ends anteriorly in an obtuse point, which corresponds with the anterior termination of the angulated ridge, and does not extend by any means so far forward as the edge of the right side, which remains thin, and forms the anterior extremity of the body.

"At the anterior extremity, the large oral aperture is seen, just below the angulated ridge, and occupying the bottom of a deep fossa, which here takes the place of the dorsal and ventral grooves. The left wall of this fossa is thickened, and projects inwards so as to form a cushion-like lobe, clothed with remarkably long cilia; and these cilia are continued into the oral aperture itself,—the posterior ones being large, usually directed transversely to the axis of the body, and having at times much the appearance of vibratile membranes.

"The bottom of the oral fossa is strengthened by a curious curved rod, which terminates superiorly in a bifid tooth, while inferiorly it appears to become lost in the wall of the fossa.

"But there is a much more prominent and easily distinguishable apparatus of hard parts situated on the opposite or ventral side of the mouth, and extending thence through two-thirds of the length of the body. It consists of two portions—an anterior, somewhat rounded mass, in apposition with a much elongated, styliform, posterior portion.

"It is very difficult to assure oneself of the precise structure of the anterior portion; but it would seem to be a deep ring, composed of three pieces—two supero-lateral and mutually-corresponding, united with a third, inferior, azygos portion. The latter is somewhat triangular, with a broad base and rounded obtuse apex,—the latter being directed forwards, and immediately underlying the oral aperture, while the former is turned backwards, and unites with the two supero-lateral pieces. Each of these is concave internally, and convex externally, so as to form a segment of a circle, and presents a clear median space, the optical expression either of a perforation or of a much-thinned spot.

"The anterior edge of each supero-lateral piece is nearly straight; but the posterior is convex, and it is by this edge that it articulates with, or is apposed to, the anterior extremity of the posterior division of the apparatus. Viewed laterally, this posterior portion appears to consist of two styles, which are somewhat like nails in shape,—their anterior extremities being truncated, so as to present a sort of nail-head, while the posterior extremity seems to taper to a fine point. Rather in front of the middle of its inferior edge each style seems to give off a short process downwards; and this process is, in botanical language, decurrent upon the style. Careful examination of the dorsal or ventral aspect of these parts shows that the decurrent process is, in fact, only the expression of a delicate membrane, which is bent so as to have a ventral convexity, and connects together the two styles. It might be said, therefore, that the posterior part of the apparatus is a triangular membrane, deeply excavated in front, bent so as to be convex downwards, and having its margins thickened and produced into styliform enlargements. This curious piece of mechanism is directed upwards and backwards, and terminates in the substance of the body without any apparent connexion with other parts.

"The whole apparatus is moveable. The posterior portion is pushed against the anterior; and the heads of the styles come into contact with the posterior convex edges of the supero-lateral pieces, and push them forwards; the posterior portion is then retracted, and the whole apparatus returns to its previous arrangement.

"In one *Dysteria*, which had swallowed a filament of *Oscillatoria* so long that the one extremity projected from the mouth when the other was as far back in the body as it could go, these movements took place as many as twenty times in a minute.

"Mr. Dyster further informs me that in one of these animals which he saw feed, the frond of *Oscillatoria* was rather 'swum upon' than seized—ingestion being accomplished by a smooth gliding motion, apparently without displacement of the styles,—but that, when the act was completed, the styles 'gave a kind of snap and moved slightly forwards.'

"Mr. Dyster is inclined to think that the *Oscillatoria* passed *through* the anterior ring-like portion of the apparatus. I have not seen the animal feed, but, on structural grounds, I should rather have been inclined to place the oral aperture at, and to suppose that the food would pass *above*, the anterior ring. The apparatus is destroyed by caustic potash, but remains unaltered on the addition of acetic acid; it is therefore probably entirely composed of animal matter.

"Immediately above the annular portion of the apparatus, there is invariably present a remarkable amethyst-coloured globule, apparently composed of a homogeneous fluid. It has on an average a diameter of $\frac{1}{2000}$ in., and it is entirely lodged in the more convex portion of the body. In many specimens no other colouring matter than this can be detected; but in some, minute granules ($\frac{1}{75000}$ in.) of a similar colour are scattered through the body. What connexion these have with the large constant globule is not clear, since, although the dimensions of the latter vary from the size given above to one-fourth or less, no relation could be observed between this diminution and the presence of the granules in other parts of the body.

"Behind the amethystine globule, the substance of the body has the appearance, common to the Infusoria generally, of a mass of 'sarcode,' in which the ingested matters are imbedded, and no clear evidence could be obtained of the existence of any digestive cavity with distinct walls.

"A little behind the middle of the body, and towards its ventral edge, there is a clear spheroidal 'contractile space,' which varies a good deal in size. One measured $\frac{1}{1500}$th of an inch in diameter, and became entirely obliterated in the contracted state.

"The contractions are not rhythmical, but take place irregularly. On the approach of death, the space becomes irregularly and enormously enlarged, until it occupies perhaps a third of the whole contents of the body.

"Immediately beyond the contractile space there is a curious oval body, having its long axis ($\frac{1}{5000}$ in.) directed upwards, and containing a comparatively small central cavity, so that it appears like a thick-walled sac.

"Indications strongly suggestive of an inferior opening were sometimes observed in this body; but no demonstrative evidence of the existence of any such aperture could be obtained.

"The walls of the ventral groove are provided with long and powerful cilia—a remarkably strong one being attached behind the base of the 'appendage;' and by their means the animal, when free, is propelled at no very rapid rate through the water. Its more usual habit, however, is to remain fixed by means of the peculiar appendage; and then the cilia act merely in creating currents, by which nutritive matters are brought towards the mouth.

"The appendage referred to is attached to the surface of the body, rather towards the convex side, at the bottom of the ventral groove, and is distant about one-fifth of the whole length from the posterior extremity. It is $\frac{1}{800}$th to $\frac{1}{1000}$th of an inch in length, and is not altogether unlike a boot with a very pointed toe in shape; and the toe appears to be viscid at its extremity, so as readily to adhere to any foreign object. The appendage then forms a pivot on which the whole body turns about; and this appears to be the habitual and favourite position of the *Dysteria*.

"Internally, the appendage contains a canal, wider above than below, and apparently blind at each extremity.

"No 'nucleus' could be found, though carefully sought for with the aid of acetic acid.

"The occurrence of transverse fission was noticed very distinctly in one case; but it is remarkable that, notwithstanding the great number of specimens which were observed, no other instance of this mode of multiplication came under the notice of Mr. Dyster or myself. It would appear that the 'apparatus' disappears, and is reproduced during fission; for, in the single case observed, mere rudiments of it were to be seen in each half of the strongly-constricted mass.

"*Dysteria* has not hitherto been observed to become encysted, although this condition has been carefully sought for.

"The creature was found in swarms among the Algæ, coating the shells of a *Patella* and a *Littorina* which had long inhabited a marine vivarium.

"There can" (p. 82) "be little doubt as to the true systematic position of *Dysteria*. The absence, in an animal which takes solid nutriment, of an alimentary canal with distinct walls, united with the presence of a contractile vesicle, with the power of transverse fission, and with cilia as locomotive organs, is a combination of characters found only in the Infusoria. In this class, again, the existence of a sort of shell or *lorica*, constituted by the structureless outer layer of the body; the presence of a submarginal ciliated groove around a large part of the margins of the body; and the inequality of the two lateral halves, leave no alternative save that of arranging *Dysteria* near or in the *Euplota* of Ehrenberg.

"Indeed, there is one species figured by Ehrenberg (*Infusionsthierchen*, p. 480, pl. 42. fig. 14), *Euplotes macrostylus*, found at Wismar, on the Baltic, which, in general aspect, and in the possession of a foot-like appendage, so closely resembles the present form, that, were it not for the absence of any allusion to the amethystine globule, or to the 'apparatus,' I should be strongly inclined to think it identical with *Dysteria*. That an internal armature is not inconsistent with the general plan of the *Euplota*, is shown by *Chlamidodon*, whose apparatus of styles would probably repay re-examination.

"Notwithstanding certain analogies which might be shown to exist between the manducatory apparatus of some Rotifera (see, *e.g.*, that of *Furcularia marina*, figured by Mr. Gosse, in his excellent memoir, *Phil. Trans.* 1846) and the 'apparatus' of *Dysteria*, I see no grounds for regarding the latter as in any way an annectant form between these groups."

Mr. Gosse dissents from this conclusion of Prof. Huxley relative to its connexion with *Euplota*, and considers it a member of the family *Monocercadeæ* among the Rotifera.

"Presuming," he says (*J. M. S.* 1857, p. 138), "*Dysteria* to be an Infusorium, it must be a species *sui generis*, with no close affinity with the *Euplotidæ*. An animal whose soft parts are enclosed between two deeply-compressed valves, and which crawls by the aid of a hinged shelly foot, is widely different from one greatly *depressed*, covered with a dorsal plate, and whose organs of locomotion are short flexible setæ scattered over the soft ventral surface.

"But I am by no means sure that it should be placed among the Infusoria at all. Mr. Huxley observes that 'the absence, in an animal which takes solid nutriment, of an alimentary canal with distinct walls, united with the presence of a contractile vesicle, with the power of transverse fission, and with cilia as locomotive organs, is a combination of characters found only in the Infusoria.

"Now the presence of a contractile vesicle, and of locomotive cilia, are quite as characteristic of the Rotifera as of the Infusoria. The absence of an alimentary canal is, I think, not proved: it seemed to me that the animal possessed a defined digestive cavity, though very ample. In *Sacculus*—an indubitable *Rotiferon*, which carries its large eggs in the manner of a *Brachionus*—the alimentary canal, without apparent distinction of stomach and intestine, is so large that it occupies fully five-sixths of the whole volume of the lorica; and though it is invariably found filled with a green Alga, on which the animal feeds, the walls of the digestive cavity are not better defined than in *Dysteria*. There remains, then, only the fact of increase by transverse fission. This, I confess, is a strong point, if well established. But it does not seem certain, from Mr. Huxley's words, whether he witnessed the progress of constriction from an early stage until two perfect animals were formed out of one, or only saw an individual so strongly constricted that the result seemed legitimately inferable. If the latter was the case, is it not just possible that it was an example, not of spontaneous fission, but of malformation, instances of which are frequent among the highest animals? It is highly worthy of note that the nucleus, so characteristic of the Infusoria, *was not found, even under careful search with acetic acid.*

"The presence, position, and movements of the foot, hinged as it is upon a tubercle, and the form of the principal organs of manducation, seem to me to determine the place of *Dysteria* within the class Rotifera; while, at the same time, the lack of internal motion, the apparent want of distinct muscle-bands, the great extent of the vibratory cilia, and the absence of a rotatory arrangement, show that it occupies one of the vanishing points of the class."

Mr. Gosse next proceeds to examine to which group of Rotatoria it approaches most nearly, and concludes, as above intimated, that it ought to have a place in the family *Monocercadeæ*, represented by the genera *Monocerca* and *Mastigocerca*, although, at the same time, a very aberrant genus. He adds "that it has also remote relations with the *Salpinadæ*, and especially with the *Coluridæ* (through *Monura*); and that it is an annectant form between the Rotifera and the Infusoria (*i. e.* the Ciliata), with a preponderance of the characters of the former class."

SECT. IV.—OF THE ROTATORIA OR ROTIFERA.

(Plates XXXII.–XL.).

GENERAL CHARACTERS.—Symmetrical animals, having a distinct head and body; the former surmounted by a wreath of cilia, the latter presenting transverse folds or joints, with a simple alimentary canal and internal maxillary apparatus; a muscular and a water-vascular system; nerves and nervous ganglia, but not arranged in a symmetrical chain; reproductive organs separate in opposite sexes; and propagation without undergoing actual metamorphosis, by ova of two forms. The Rotatoria, moreover, are destitute of limbs in pairs, but have mostly the posterior extremity of the body produced as a powerful, although a symmetrical, organ of locomotion, in which a transverse articulation is particularly evident.

This is a very natural group of animals,—its characters being definite, and readily recognized by reason of the comparatively large size and transparency of the organisms. The name *Rotatoria*, sometimes exchanged for *Rotifera*, is derived from the apparent whirling or wheel (*rota*)-like motion of the ciliary wreath around the head, seen in most species. Since this rotary movement is not universal, and at best but an ocular deception, some observers have been discontent with the appellations derived therefrom; and Dujardin, for one, has suggested as preferable the term '*Systolides*,' as indicative of the remarkable contractile and flexible nature of their bodies. They are also still spoken of under the old name of 'wheel-animalcules;' indeed, the early observers of the class actually believed the animals to be furnished with wheels, by the rotation of which they moved.

EXTERNAL FORM, INTEGUMENT, AND APPENDAGES.—The Rotifera are symmetrical, and in this respect contrast with the asymmetrical Protozoa. They present a determinable dorsal and abdominal surface, and consequently a right and a left side. They have an oblong, ovoid, or much-elongated figure, and are mostly separable, by the presence of a constriction more or less developed, into an anterior segment or head, and a larger posterior one or trunk. The extension of the latter in a tail-like fashion may be regarded as a third segment. The constriction or narrower portion behind the head is frequently called the neck; this is wanting in many cases, and then the head is undistinguishable from the trunk as a distinct section, *e. g.* in *Notommata Myrmeleo*. On the contrary, the separation of the head from the trunk is well seen in *Brachionus* (XXXIX. 15–18; XL. 11), *Stephanops* (XL. 8–10), *Euchlanis* (XXXIX. 4), *Noteus* (XXXVIII. 25), and *Melicerta* (XXXVII. 17). The articulation of the tail-like segment is always evident. In a certain number this prolongation is wanting; and the animal is then tailless,—*e. g. Anuræa* (XXXV. 495–498) and *Sacculus* (XXXIX. 18).

To facilitate the recognition of the general divisions of the body of Rotatoria, considered as bilateral symmetrical animals, Mr. Gosse furnishes the following remarks (*Phil. Trans.* 1855, p. 424):—The bilateral organization is, he observes, in most cases "obvious,—the motions of the animal, like those of the footed larvæ of insects, being performed on the belly, with the head foremost. Where this is not the case (as with those genera which, either with or without an enveloping tube, adhere to foreign substances by the tip of the foot, and elevate the body in an erect position), the dorsal aspect is always determinable by the eye or eyes being towards that surface, by the stomach and intestine passing down it, and by the cloaca being on that side of the foot. The ventral aspect has the manducatory apparatus and the ovary."

But, besides these great divisions, all the Rotifera exhibit transverse lines, folds, or joints, analogous to those seen in the Articulata, especially among the Crustacea, such as the lobster and shrimp. Mostly, such are but folds or wrinkles, and not true articulations, in the Rotatoria (though perhaps as much so as the like in the larvæ of many insects), and consequently disappear on the extension of the animals. However, in not a few instances, veritable articulations occur,—*e. g. Hydatina, Rotifer, Eosphora, Philodina* (XXXVIII. 1, 2). In *Euchlanis dilatata*, writes Ehrenberg, the abdominal surface presents four decided articulations. The minimum development of the articulate condition occurs in those genera the most removed from the Rotatorial type, viz. in *Stephanoceros* (XXXVII. 1), *Lacinularia* (XXXVII. 19), and some anomalous *Notommata* (XXXVIII. 28), which only present fine lines under the surface, looking like annular threads. The construction of the joints is peculiar, one portion or segment sliding within another after the manner of the tubes of a telescope. This telescopic action is best illustrated in the genus *Philodina*, where the entire body is fusiform and articulated; but it is oftentimes to be seen also in the tail-process, when absent or imperfect in the rest of the body,—*e. g. Brachionus, Noteus* (XXXVIII. 25), *Stephanops* (XL. 8–10), *Scaridium* (XXXVIII. 22). An incomplete articulation, or mere wrinkling, is seen in the pedicle of *Megalotrocha, Melicerta*, and *Lacinularia* (XXXVII. 17–19).

All the Rotatoria are invested by a firm, usually smooth and elastic, integument or skin, which follows the contained parenchyma in all its contractions, accommodating itself to the various movements of the body. It is more delicate on the head, where the cilia are inserted, and there becomes continuous with the membrane of the interior. It is composed of two layers —an external, the *cuticle*, and an inner, immediately subjacent, the *dermis* (XXXVIII. 26). Where the structure is not evident, it may be rendered so by the use of chromic acid. The *cuticle* is homogeneous, structureless, and firmer than the *dermis*, which is soft, granular, and contains in its thickness numerous fat-globules and nucleated particles (XXXVII. 29). The latter tissue acts as a lining to the general cavity of the body, and gives attachment to the muscular cords of the interior. It is much developed about the head, beneath the vibratile ciliary apparatus, and there sends inwards numerous projections or lobes (XL. 2), which Ehrenberg assumed to be of a muscular nature, and to be permeated by vessels and nerves. At other parts also, delicate fibres or threads are seen to pass inwards from the *dermis* to the viscera, sustaining and connecting them together. These fibres have sometimes been described as muscles, at other times as nerves. The former is apparently their true nature, although, as Cohn believes, nerve-fibres may be mixed among them.

The integument is histologically, *i. e.* in its anatomical nature, a connective tissue derived from the coalescence of branching cells, and still presents in its inner layer the scattered nuclei of the original cells, in the form of the nucleated particles described. Where the dermis is much developed, its soft tissue becomes here and there hollowed out into clear spaces or vacuoles, which have been mistaken for nerve-ganglions, especially when situated in the head (XXXVII. 29). So, again, at the posterior part of the body, behind the viscera, and in its prolongation or foot-process, where the dermic tissue abounds, the vacuolar thickenings have been conceived to represent ganglions or, otherwise, glands.

The cuticle, or external limiting membrane of the integument, is hardened by the deposition in it of the peculiar chemical principle *chitine*, the same which imparts firmness to the covering of Entomostraca, Insects, and other Articulata; or if not actually chitine, it is a substance closely allied thereto. This is Leydig's opinion, and it seems sufficiently confirmed by the reaction of chemical agents. Thus, he shows that caustic alkali (potash) does not dissolve the cuticle when it possesses, as it usually does, moderate firmness, in other words, when an infusion of chitine exists in its substance. But when the animal lives within an external case, and does not need the protection of an immediately investing skeleton, the chitine is absent, and the integument dissolves in the alkali. The analogue of this may be found among the Articulata.

The prevalent opinion has been, that the dense cuticle or external skeleton of Rotifera differed from that of the Crustacea and other Articulata in not being of a chitinous nature; and this hypothesis was used in arguments relative to the affinities of the Rotatoria. Thus Kaufmann advances it as a decided distinction between this class and the Tardigrada; but, as Leydig remarks, the skin of the latter animals is even more affected by potash than that of the Rotifera (*see* section on the Affinities of Rotatoria).

The cuticle, as just intimated, differs much in firmness and thickness in different species. It is softest in those which live in an external case—*e. g. Stephanoceros, Melicerta, Tubicolaria,*—and in such as are invested by a gelatinous sheath—*e. g. Notommata centrura.* In *Diglena, Notommata aurita* (XXXVI. 3, 4), *Asplanchna,* and others, it is firmer, but still flexible; whilst in such genera as *Brachionus* (XXXIX. 16, 17, 21), *Noteus, Salpina,* and *Euchlanis* (XXXIX. 4) it attains a rigid, horny consistence, resembling that of the shells of *Entomostraca.* Even where the skin is of considerable firmness, it is yet capable of distension, as Perty observed in the *Scaridium longicaudum* when its stomach was stretched with food. The form of the body is much modified by the degree of firmness of the integument. When this is soft and yielding, or flexible, the figure is rounded, and more or less elongated, and may taper towards one or both extremities; but when the cuticle is much hardened, the rounded configuration is often lost, and various irregularities in form result. For example, in *Metopidia* and in *Euchlanis dilatata* (XXXVIII. 5) the body is ovate and compressed, or depressed; in *Euchlanis triquetra* it is triangular (XXXIV. 443); in *E. hipposideros* and in *Lepadella* (XXXIV. 430–432) the dorsum is convex, the abdominal surface flat; in *Noteus quadricornis* (XXXVIII. 25–27), suborbicular and compressed; in *Mastigocerca carinata* and *Ratulus carinatus* (XXXIV. 438–440) it is prismatic, with one angular ridge or crest; in *Colurus,* compressed laterally.

There is, besides, a direct relation between the segmentation of the integument, the perfection of its articulate condition, and the degree of firmness of the integument. The soft-skinned Rotatoria only throw their bodies into folds during contraction, whilst those with firmer cuticle, such as *Philodinæa,* develope the sliding joints, and, lastly, those (*e. g. Lepadella* and *Euchlanis*) which have a dense horny covering present two or three decided segments, recalling in form and disposition the divisions of the external skeleton of the monocular Entomostraca, or even of the higher Crustacea.

Where the cuticle is condensed into a rigid, horny lamina, defending the animal like the shell of a Crustacean or the carapace of a tortoise, it may well be termed a testa, testula, or lorica. This last name was very loosely used by Ehrenberg, being alike applied to the soft, pliant skin, to the hard shell-like cuticle, and to the loose and large external cases in which some Rotatoria live, as do the Coralline Polypes, in a cell or chamber. If limited, however, in its signification, as above suggested, the term may still be usefully retained, and is preferable to the word 'shell,' which peculiarly belongs to the habitation of the Mollusca. By some authors the term carapace is employed; but to this there occurs a similar objection.

The lorica received from Ehrenberg various names, according to its form. Where a firm cuticle entirely enveloped the trunk, leaving the head and tail free, it constituted a *testula*, as in *Pterodina*; where it covered only the upper surface and sides, it formed a *scutellum* or shield, as in *Monura* (XXXIV. 457–459). The term 'carapace,' employed by some authors, is equivalent to *scutellum*. The anterior and posterior openings of a testule vary much in different species; and an equal diversity occurs in the space left uncovered by a scutellum. This space is small and very narrow in *Euchlanis Lynceus*, in *E. pyriformis*, and in *E. deflexa*. In the last, moreover, the free edges are bent outwards at right angles. In several genera, again, the lorica appears composed of an upper and an under plate, or is, in other words, bivalved. This is seen in *Dinocharis* (XXXIV. 454, 455), *Salpina*, and *Colurus*, and resembles the envelope in some of the lower *Crustacea*, as *Cypris*. In a few Rotifera, *e. g. Euchlanis* (XXXVIII. 5), the lorica appears much too large, the contained viscera only partially filling it. An increased firmness of the lorica enables it to resist decomposition longer than its soft contents; hence the occurrence of empty ones. Where the integument is of sufficient firmness to present an anterior and posterior margin, it is subject to many variations in form. Thus it may be truncate in front, as in *Hydatina*, *Diglena* (XXXIII. 403–405), and *Polyarthra* (XXXVIII. 30); or behind, as in *Notommata Felis*. It is crescentic in *Metopidia*; deeply and widely notched in *Lepadella patella*; has several spines, in front only, in *Anuræa*; and both anteriorly and posteriorly in *Noteus*, *Salpina* (XXXIV. 447–453), and *Brachionus* (XXXIV. 499–501). Sometimes the spines are so short and wide, that the border appears simply dentated or undulated; in other cases, spines may be long and strong, and themselves dentated, as in *Noteus quadricornis* (XXXVIII. 25). Not only do the anterior and posterior margins differ, but even those of the upper and under surface of the lorica, for example, in *Salpina spinigera* and in *S. mucronata*. Animals with spines projecting from the anterior margin, Ehrenberg speaks of as '*horned*.'

The surface of the integument is variously modified. The slightest change from the normal smooth condition consists in a shagreened, dotted, or stippled surface, or in the presence of fine lines,—*e. g.* in *Anuræa inermis*, *Dinocharis* and *Diglena lacustris*. In *Notommata centrura*, fine silky prominences clothe the surface. In *Noteus quadricornis* and *Brachionus militaris*, the points are elevated, and give the surface a rough (scabrous) aspect. Lines crossing each other, producing a tessellated or reticulated condition, are seen in *Anuræa curvicornis* and in *Brachionus Bakeri*; whilst in *Anuræa testudo*, *Brachionus militaris* (XXXIX. 21, 22), and *Noteus quadricornis* (XXXVIII. 25) the lines assume the character of ridges, and divide the surface into squares or *facettes*. Radiating or curved striæ are seen in *Anuræa striata* and *A. foliacea*, which in *Euchlanis Lynceus* are replaced by flutings.

The elevated points may assume a further development, and project from the surface in the form of curved spines or hooks (*aculei*), as in *Philodina aculeata*; or they may be so extended in length as to form long spines or rigid styles or setæ having particular functions, as in *Triarthra* (XXXVIII. 30, 31, 32), and *Polyarthra*, where they are important organs of locomotion.

In the last-named genus they attain a still more complex nature, and assume a plumose (feather-like) structure (XXXVIII. 30).

The opposite condition is seen in depressions or pits, few and scattered, on the surface of the integument, often apparently surrounded by a margin. Illustrations are found on the dorsum of *Polyarthra*, of *Notommata Myrmeleo*, and of *N. Sieboldii* (XXXVII. 32).

All the markings and processes of the integument of Rotatoria are productions of the chitinous cuticle, just as hairs, feathers, horns, and claws in the Vertebrata originate from the epidermis. They are similarly affected by chemical reagents, and decompose with the same facility as the integument which supports them. They are, moreover, of much value in supplying generic and specific characters.

Several genera possess, in addition to the integument immediately investing them, an external sheath or case, to the bottom of which they are attached by a prolongation of the body in the form of a contractile pedicle. This external sheath received from Ehrenberg the particular designation of '*urceolus*;' and consequently the beings inhabiting it were said to be urceolated, or, as many prefer to say, are 'encased.' The composition of the case varies greatly; for, although it originates always as a secretion from the animal itself, the substance differs in different genera, both in its characters and modes of formation: moreover, in some species, particles of foreign matters are superadded, to give it strength and solidity.

The cases of *Floscularia* (woodcut, Part II.) and *Stephanoceros* (XXXVII. 1) are colourless, and apparently structureless, and, though roomy, are visible with difficulty on account of their tenuity and transparency. They are best demonstrated by the addition of some colouring matter, such as indigo, to the water in which they are examined. An exception to the usually transparent homogeneous case of *Floscularia* occurs, according to Dr. Dobie, in *F. campanulata*. Dujardin, again, asserts that the urceolus of *Floscularia* may vanish during the lifetime of the animal, and that in many French species it is always absent; he therefore denies its value in generic distinctions. His statements, however, require confirmation, being opposed to the observations of other naturalists.

Again, the tubes of *Œcistes*, *Conochilus*, and *Lacinularia* are hyaline, with a more gelatinous consistence, and, in the two last genera, adhere together. In *Conochilus* the individuals are aggregated around a central globule of gelatine, from which they project like so many rays; whilst in *Œcistes* each urceolus is free, but has its surface encrusted with foreign particles. *Tubicolaria* (XXXII. 379) has a thick gelatinous case, of a milky hue, which, from its effervescing on the addition of an acid, is attributed to a deposit of carbonate of lime within it. In young animals the case is quite transparent. This is also true of the urceolus of *Limnias* (XXXVI. 2), which, as it grows older, changes to a brown and brownish-black colour; and, as it is viscid, various extraneous bodies affix themselves to it. In one newly-discovered species, the usually smooth surface is departed from, and the case becomes annulated, and is also semitransparent. Dr. Bailey found in North America a species of *Melicerta* with a brown annulated urceolus. But the most remarkable tubular sheath is that of *Melicerta ringens* (XXXII. 386; XXXVI. 1), which is composed of equal-sized lenticular pellets, of a brownish-red colour, and of a substance secreted by the animal itself and deposited in a regular oblique or spiral series. This wonderful phenomenon will be considered hereafter, in the section on Secretion. The cohesion of particles of foreign substances to the enclosing tubes is seen also in some Annelida, and in the aquatic larvæ of certain Insects.

The urceolus serves as a place of shelter and defence for the adult animal, and also for the ova it deposits. The latter often remain within the case until they are hatched. The necessity for shelter is entailed by the fixed condition of these Rotatoria, because, unlike the free animals, they cannot escape their pursuers by flight. By means, therefore, of their highly contractile pedicles they can entirely withdraw themselves within their tubular dwelling, until the threatening danger is overpast. Ehrenberg, however, states that the animal may detach itself from its case and swim away free: if this be true, we must suppose it will again affix itself and proceed to construct another urceolus. The possibility of this acquisition of freedom is favoured by the analogous detachment of *Vorticellæ*, and the formation by them of a new pedicle on reattaching themselves. Empty urceoli are indeed not uncommon; but, unless the process be witnessed, it is impossible to say whether the inhabitant has quitted its abode at will, or disappeared by decomposition after death or by becoming a prey to other animals. Mr. Gosse noticed that a *Melicerta*, which had its case slit up for some distance, protruded itself through the opening; and during several days' observation, though it made pellets, they were never deposited in order to repair the breach, but were allowed to float away: this observation does not support Ehrenberg's above-cited opinion. Each member of a colony of adherent Rotatoria is generated free, and swims at large until it chooses to join its fellows in becoming fixed. The encased Rotatoria attach themselves to any convenient substance in the water, especially the stems and leaves of water-plants. The single individuals are many of them just visible to the naked eye; and where they unite in compound masses, they can be detached in the form of jelly-like globules, having a milky hue, often $\frac{1}{7}$th of an inch and upwards in diameter. Tubes of *Melicerta* and *Tubicolaria* occur from $\frac{1}{36}$th to $\frac{1}{24}$th of an inch in length.

An external envelope is found in a few free Rotatoria in the form of a soft gelatinous coating,—for example, in *Notommata Copeus* and *N. centrura* (XXXVIII. 26). In the latter species, moreover, this coat exhibits a regular arrangement of fine molecules within it, and a consequent apparent striation. Ehrenberg describes the confervoid fibres of *Hygrocrocis* as sometimes parasitic on this gelatinous involucre; but this account Leydig doubts. It is certainly, however, not improbable, since urceoli of every variety furnish a favourable nidus to parasites, both vegetable and animal; and this writer himself speaks of Vibrios adherent to the hyaline case of *Stephanoceros*, on the surface of which, as he imagines, they sometimes give rise to an apparent striation.

Appendages of Rotatoria.—Each great division of the body is furnished with certain prominent parts or appendages, adapted to supply various requirements of the economy. The appendages of the head and neck exceed all others, both in number and importance,—the rotary organ, the peculiar characteristic of the class, being one of them.

This latter organ is essentially a ciliated wreath or circlet, mostly supported on an expanded margin or disk, and subject to considerable variations, which are employed in the classification of these animals; the rotary is also called the rotatory organ or disk, the trochal disk, at times, less definitely, the ciliated disk or wreath, or the wheel organ.

Ehrenberg employed the rotary organ in its different modifications as the basis of his classification of the Rotatoria, making two chief types, in one of which the ciliated ring was single and complete, in the other subdivided into several independent portions or secondary wheels. A subordinate type presented two equal symmetrical circlets of cilia, forming a pair of wheels. To the first of these groups he gave the name of *Sorotrocha*, to the second *Polytrocha*, and to the last *Zygotrocha*. The further subdivisions which he formed, and the names he applied to the varieties of the rotary organ, will be explained in the section on Classification. The belief in actually compound trochal disks has been shared by nearly all observers, and both Perty and Siebold adopt it along with Ehrenberg's classification. On the other hand, it is denied by Leydig, who affirms that the disk is never divided into such secondary wreaths or lobes, but always constitutes one continuous margin, variously extended and folded, and, it may be, furnished with independent accessory ciliated disks. This able writer remarks—"It is only to the exceptional genera *Stephanoceros* and *Floscularia*, that Ehrenberg's term *Polytrocha* can be rightly applied. In truth, an observation recorded by the great micrographer himself negatives his hypothesis of polytrochous division, that, viz., where he applied strychnia to the rotary organ of *Hydatina*, which became thereby reduced to a simple whorl of cilia."

The various degrees of complication assumed by the trochal disk are thus detailed by Leydig:—"It forms a simple ciliated margin around the mouth of *Notommata tardigrada*; in *Stephanops* (XL. 8, 10) it is wider, more prominent, and triangular; in *Euchlanidota*, *Polyarthra* (XXXVIII. 30), *Diglena*, *Distemma*, *Hydatina* (XL. 1), *Pleurotrocha*, and others, it occupies the entire periphery of the head, and is not at all, or but very slightly, elevated as a distinct disk above it; in *Notommata Copeus*, *N. aurita* (XXXVI. 4), and in *Synchæta*, it is enlarged and elevated as a distinct disk on each side of the head, forming the "ears" so called by Ehrenberg; in other instances it is enlarged, and projects on the ventral surface of the animal like a ciliated trunk or proboscis. A higher development is seen in *Brachionus* (XXXIX. 15–18) and *Philodina*, where the ciliated border is involuted and extended upwards laterally (XXXVIII. 2); and lastly, in *Megalotrocha*, *Lacinularia*, *Melicerta* (XXXVI. 1; XXXVII. 17), and *Limnias* (XXXVI. 2), the highest complexity is reached, and the trochal disk appears to be an appendage surmounting the head, expanded in the form of a sinuous or lobed ciliated margin." In the variety last mentioned, Mr. Gosse speaks of the expanded lobes under the name of "petals."

The row of cilia fringing the rotary organ is often single, but in several species is double, and even treble. Mr. Huxley has noticed its double condition in *Lacinularia socialis*. To quote his description—"The edge of the disk has a considerable thickness, and presents two always distinct margins, an upper and a lower, of which the former is the thicker, and extends beyond the latter. The large cilia are entirely confined to the upper margin, and form a continuous horse-shoe-shaped band, which, upon the oral side, passes entirely above the mouth. The lower margin is smaller and less defined than the upper; its cilia are fine and small, not more than one-fourth the size of those of the upper margin. On the oral side this lower band of cilia forms a V-shaped loop, which constitutes the lower and lateral margins of the oral aperture. About the middle of this margin, on each side, there is a small prominence, from which a lateral ciliated arch runs upwards into the buccal cavity, and, below, becomes lost in the cilia of the pharynx. The aperture of the mouth, therefore, lies between the upper and lower ciliated bands (XXXVIII. 21)."

Prof. Williamson has signalized a like arrangement in *Melicerta* (XXXVII. 17), and Leydig in *Brachionus*, *Pterodina* (XXXVIII. 29), and *Megalotrocha*. The latter writes—"On the free surface of the head of *Brachionus* (XXXVIII. 14, 15), two lateral and and a median lobe elevate themselves, which Huxley compares to the two ciliated borders of *Lacinularia*,—an interpretation that has very many arguments in its favour, and in support of which I may adduce the structure of the rotary organ of *Pterodina*. This species, belonging to the family of *Brachionæa*, has its free projecting lobes furnished with a double row of cilia, analogous to what occurs in *Megalotrocha*. That the wheel organ of *Philodinæa* also is referrible to the same type, is evident from the account Huxley gives of it."

Cohn (*Zeitschr*. 1855, vii. p. 437) describes two complete rows of cilia, besides five or six special ciliary bundles, on the head of *Hydatina senta* (XL. 1). On the outer margin is an unbroken row of long and fine cilia, extending thence into the oral fissure, and still further, into the œsophagus. Within this circle is an interrupted one formed by 6 or 7 (Ehrenberg counted 11) bundles, having few or many broader and longer cilia, nearly resembling the setæ on *Stylonychia*, and supported on as many cushion-like eminences. Lastly, the third series is unbroken like the first, and composed of finer cilia, disposed in a quincuncial manner in two lines. All the parts of this ciliary apparatus work harmoniously together in effecting the movements of the animal or in securing the capture of food.

The figure of the trochal disk (XXXVIII. 14, 15, 20, 21) varies exceedingly, as the quotation from Leydig indicates, and is especially influenced by the addition of supplementary ciliated eminences. In *Megalotrocha* (XXXII. 374–378) the disk is horse-shoe-shaped; in *Melicerta* it is petaloid, or, as Prof. Williamson called it, *flabelliform*; in Rotifer it is seen under two forms, according to its degree of expansion, either as a single conical eminence, or, when completely unfolded, as two cylinder-like processes, one on each side of the head, apparently whorling like two wheels. In the family *Brachionæá* (Ehr.) accessory disks or processes give rise to much complication (XXXIX. 15–22). Ehrenberg described this family as having two ciliated organs—a central one of three parts, and a lateral one of two,—the latter being the true wheel organ, and the former, frontal processes which are stiffly extended whilst the rotary organ is in action. An appendage such as that last named, in *Notcus*, he designates a three-lobed ciliated brow.

Exceptional or aberrant forms of the ciliated disk are seen in *Floscularia*, in *Stephanoceros*, and in *Lindia* (XXXIX. 1, 3). In the first, the head (XXXVII. 1) is surmounted by five ciliated flattened lobes, ending in knob-like processes which bear very long, divergent, non-vibratile hairs or cilia of uniform thickness (*see* woodcut, Part II.). "These exceptional cilia," says Dr. Dobie, "are slowly moved and spread out by the contractile substance of the lobes of the rotary organ." In *Stephanoceros*, the departure from the normal structure is still greater (XXXVII. 1),—so much so, that the ciliated appendages have no claim to the title of a rotary organ. Five long arms extend from the head, like five tentacles, covered by cilia in rings (verticellate cilia). These arms not only act like a common trochal disk by producing a vortex directing all particles within its range to the mouth, but also as organs of prehension, closing themselves on any larger object which may come within their grasp. This ciliated armature around the head bears a close resemblance to that of the cilio-brachiate Polypes or Bryozoa, to which class of animals, indeed, several distinguished naturalists have referred the genus *Stephanoceros*, not merely on account of this one affinity named, but also from several other coincident characters. A third peculiar form of rotary organ has been recently pointed out by Cohn in *Lindia* (*Zeitschr*. 1858, p. 284). It takes the form of a club-shaped process on either side of the head (XXXIX. 1, 3), having its extremity somewhat expanded and spherical. Cilia exist only on the round summits of these processes; there is no whorl around the margin of the head, none elsewhere on the body; and this example may be adduced as that of the least complicated rotary organ among Rotifera.

It is in these aberrant forms alone that the ciliated apparatus can be strictly called "*polytrochous*;" in them, also, the wheel-like motion is completely absent. This peculiar motion, on the contrary, is most evident where the wreath is a simple circle, as in *Conochilus* and *Actinurus*, or where, as in *Rotifer* and *Philodina*, it is peculiarly involuted, although continuous. Where, on the contrary, it is interrupted by a notch at any point, or is sinuated, or complicated by supplementary processes, as in *Hydatina* (XL. 1), *Diglena*, many *Notommata* (XXXVII. 29, 32), *Synchæta*, &c., the illusion of complete revolutions vanishes.

Formerly, the belief existed that an actual whirling of the ciliated cephalic appendages took place, and that the little animals moved along, by the aid of these wheels, after the manner of a steamer with its paddle-wheels. Such an opinion is no longer entertained; and various explanations of the apparent rotary motion are now offered in its stead. Dutrochet attributed it to the undulation of a delicate membrane fringing the head of the Rotatoria. Faraday explains it by supposing the distinct cilia to become visible by slowly returning to an erect state, after having previously been suddenly bent. Ehrenberg assumed the existence of four muscles at the base of each cilium,—each muscle acting in its own direction, and so producing a revolution around the fixed point of attachment or base of the cilium. In this way, each cilium would be alternately nearer to or more remote from the eye, and more or less visible.

Another explanation has been offered by Dujardin. He says—"The vibratile cilia being arranged parallel and at equal distances, will equally refract or intercept the light, and none will be more visible than the rest; but if, by a movement propagated along the row of cilia, some, momentarily inclined, are brought into juxtaposition with adjoining cilia, the light will be more intercepted, and a band more or less dark will be the result. It can be imagined, therefore, that if the cilia come to be inclined one after another, a series of juxtapositions, or of apparent intersections will be produced in the direction of the general movement. Further, if each of the intersections preserve the same form, as if produced by a number of equal lines, and are equally inclined to each other, an appearance of a solid body of a definite form, like the teeth of a saw or the spokes of a wheel, moving uniformly, presents itself to the eye."

The action of the trochal disk is under the control of the animal. The ciliary movement can be arrested at will or exercised with varying rapidity; or the whole organ may be retracted, partially or entirely, within the body. When completely withdrawn, the ciliary wreath can frequently be detected at the fore part of the animal, oftentimes deep within the trunk, and generally in the form of a striated cylinder at the bottom of a funnel-like canal. In complete retraction the anterior extremity of the body is involuted, or doubled inwards, and supports, as it were, the ciliated wreath within, whilst the contractility of the integument at the margin closes the entrance pretty accurately, giving a more or less conical outline to the fore part of the animal (XXXVII. 19; XXXIX. 17). In complete retraction of the trochal disk, the antenna-like processes which may be seated on it are also withdrawn; but at other times, when the inversion is incomplete, these processes continue to project from the head, and in the process of evolution are always the first to appear, as if intended to test the safety of unfolding the delicate ciliary wreath.

The inversion of the ciliary apparatus and appendages is effected by strong muscles arising within the abdomen, which draw downwards, and therefore inwards, the disk to which they are attached. At the commencement of their traction, they draw together the sides of the ciliary whorl, then pull inwards the cilia, which are previously collected in a cylindrical manner, and at last cause the inversion of the integument immediately beneath the disk, when the now anterior extremity of the body contracts itself upon the included parts. This process of involution may be arrested by the animal at any stage; thus, sometimes it is stayed when the cilia are grouped together in a cylinder-like heap, and still project from the head like a pencil; or, as above mentioned, the cilia may be withdrawn, and some process or antenna be left protruding. The collection of the cilia into a brush-like group during the process of retraction is well exemplified in the long cilia of *Floscularia*; and in *Rotifer* and *Philodina* we have a special example of the protrusion of a ciliated process during the involution of the major part of the trochal disk (XXXVIII. 1). In the genera last cited, this median process serves as the anterior organ of progression when the animals advance in a leech-like manner, and disappears when the pair of trochal organs are evolved and the crawling movement is changed to swimming.

The retraction of the trochal disk we may suppose to be controlled by the will of the animal to arrest its motion or to avoid danger. Another motive is conceivable, especially in the case of the attached species: for the cilia, when in active operation, attract every sort of particle within their vortex—as well those appropriate to nutrition as others noxious or which have been lately discharged and still float about the animal; hence it may be necessary to arrest their action, withdraw the disk, and close all access to the interior, until these unfit substances are floated away and have been replaced by others.

The ciliated mechanism of the head is, as just hinted, the active agent in procuring food, by dragging within its vortex the nutritive particles in reach, and transferring them to the mouth, which is so situated that the current produced sets directly into it. Where the ciliary wreath is double, as in *Melicerta*, "the food" (to use Prof. Williamson's description) "that reaches the mouth is whirled around the wheel-organs along the groove that separates the two circlets of cilia; and since these circlets diverge near the 'chin' (or fifth ciliary lobe), the mouth being located between them, the food is necessarily conveyed directly to the latter organ. The two sets of marginal cilia, by bending towards each other whilst in motion, almost convert this groove into a sinus, especially in the two large segments." But besides locomotion and nutrition, the rotary apparatus must be admitted to subserve the function of respiration, both by its own delicate structure, and by its action in constantly renewing the water around the animal; also, by forcing fluid within the alimentary canal, it may serve to aërate and renew, by endosmosis, the fluid in the general cavity surrounding the viscera.

In the fixed species of Rotatoria the rotary organ can have no locomotive use, merely subserving the functions of nutrition and respiration. In addition to the rotary organ, the head is often beset with various appendages in the shape of styliform and tubular processes, lobes, disks, uncini, and spines. These are situated either within the circle of the ciliary wreath on its margin, or immediately external to it. Examples of tapering, styliform, and bristle-like processes are found in *Notommata Myrmeleo*, *Monocerca bicornis*, in *Synchæta*, *Monostyla*, *Brachionus*, and others. On the head of *Conochilus* are four stout wart-like elevations. In *Polyarthra platyptera* two long bristles project from near the mouth, each bent on itself midway at a right angle (geniculate). Dujardin describes, in his genus *Colurella*, an uncinate retractile appendage surmounting the trochal disk. In *Brachionus urceolaris* (XXXIX. 15, 16), straight non-vibratile cilia occur between the ciliated lobes of the rotary organ; and in *Polyarthra* there are fleshy tentacular appendages, which Siebold suggests are antennæ or feelers. The 2–4 styliform processes of *Synchæta*, Ehrenberg supposed to possess prehensile powers. In *Conochilus*, four processes, terminated by bristles, project from the ciliary disk; in *Melicerta* are two curved hooks. To some of these appendages, and to others about the head, various fanciful names have been given, borrowed mostly from remote resemblance in appearance, situation, or function to parts existing in the higher animals. For instance, on each side of the head of *Notommata aurita*, *N. Copeus*, and *Diglena aurita*, a lobe of the trochal disk is more elevated or elongated than the rest, and has received the appellation of "ear" or "auricular;" the 2–4 supplementary processes of the head of *Polyarthra* (XXXVIII. 30 *a*, *b*) have been called "horns,"—a name applied to a similar projection in other Rotatoria.

In *Stephanops* a prominent scale-like process of the head is known as the "hood" (XL. 8–10). Mr. Gosse speaks of a projecting spoon-shaped lobe in *Melicerta*, covered with cilia, as the chin, which Williamson recognizes as a "fifth lobe" of the wheel organ (XXXVII. 17 *c*). The latter writer, again, adopts from Schäffer the appellation of "lips" for two hook-like appendages of the head of *Melicerta*, and further describes, on each side the oral aperture, two projecting "flattened lobes, with ciliated margins continuous with those of the 'chin,' which obviously assist in directing the food into the œsophagus." Lastly, Ehrenberg frequently employs the term "frontal region" or forehead, to signify the anterior surface of the head.

Certain tubular-looking processes, frequently furnished with a pencil of fine non-vibratile cilia or bristles at the extremity, have gained particular consideration owing to the functions assigned them by Ehrenberg and others. They protrude from the head near the trochal disk, and more commonly from the neck, as is seen in *Rotifer*, *Philodina* (XXXVIII. 20), *Brachionus* (XXXVIII. 15; XL. 11), *Actinurus*, in *Euchlanis Lynceus*, in *Melicerta* (XXXVII. 17), in *Salpina mucronata*, in *Notommata clavulata*, *N. Myrmeleo*, *N. Sieboldii*, and other species. In all the above the appendage is single, but in *Tubicolaria* and *Melicerta* (XXXVII. 17 *d*) it is double. In *Callidina* Ehrenberg mentions a thickly-ciliated proboscis, apparently retractile, and attached to the trochal disk; occasionally, instead of terminating by a bunch of setæ, these processes have a horn-like prolongation, as in *Notommata centrura* and *N. Copeus*. The short conical elevations of *Synchæta* and *Polyarthra* belong to the same category with the tubular variety. A long flabelliform process occurs in connexion with one of the ciliary lobes of *Floscularia*, which is often called a proboscis, and supposed to be tubular. Ehrenberg has assigned two different appellations to these tube-like appendages. At one time he calls such a process a *spur* ("*calcar*"), and imagines that it subserves the generative process as an intromittent organ; at another he represents it as a respiratory tube (*siphon*), through which water may enter to act on the vibratile tags (gills) seen within the abdomen. The former view has found no supporters, and is entirely set aside by our present knowledge of the reproductive act of the Rotatoria; the latter has been admitted by several, among others, by Siebold, although recent researches now render it untenable, and demonstrate the analogy of these appendages with the feelers (antennæ and palpi) of Entomostraca and other Crustaceans. Dujardin seems to have been the first to suggest the analogy mentioned. Referring to these processes and to others less considerable, terminated by a bundle of stiff cilia, he observes that they recall, to some extent, the palpi and antennæ of

Entomostraca and *Cypris*, and that no trace of the entrance or exit of water is perceptible, even when particles of colouring matter are diffused through the liquid, calculated to indicate the slightest current."

Since this was written, Perty, Gosse, Williamson, Huxley, and Leydig in particular, have minutely studied the point in dispute, and coincide with the French naturalist as to the non-perforated character of the organ, and its homology with antennæ. Mr. Gosse writes—"The tubes or spurs on each side of the head (of *Melicerta*) below the chin (XXXVII. 17 *d d*) are evidently consimilar with the antennæ of Rotifer, &c. There is a slender piston in each, capable of being retracted, and bearing at its extremity a tuft of very fine, divergent, motionless hairs." Mr. Williamson's account is more detailed; he calls them "tentacles," and states that, when fully protruded, they are seen "to be terminated by a brush of fine divergent setæ implanted on the convex side of a small deltoid body (the *piston*, Gosse) (XXXVII. 12); from the flat side of this latter appendage there proceeds, along the interior of the tube, towards the body of the animal, a delicate muscular band (XXXVII. 13, 14), which, by its contractions, draws the deltoid body backwards, thus inverting the extremity of the tube, and forming a double sheath protecting the setæ (XXXVII. 14). This inversion of the tube was, we believe, first noticed by Dutrochet. The whole apparatus is, as suggested by Schäffer, very similar to that seen in the tentacles of the snail, and appears to constitute a tactile rather than a respiratory organ. This is rendered more probable by the fact that, when the animal first emerges from its tessellated case, the extremities of these two tentacles are the first parts that make their appearance (XXXVII. 17 *d d*),—the two curved hooks being the next (XXXVII. 17 *b*). The setæ are usually half drawn into the inverted tentacle; but they project sufficiently forward to constitute delicate organs of touch, supposing the deltoid body, into which they are inserted, to be endowed with sensibility. The animal cautiously protrudes these tentacles before it ventures to unfold its rotary organs, but it does not direct them in an exploratory manner from side to side, as an insect does its antennæ."

But there are many strictly homologous processes with a terminal tuft of setæ which are tubular and not retractile, or otherwise neither tubular nor retractile, but horn-like in figure, or merely conical. Examples occur in *Notommata Myrmeleo* (XXXVIII. 26 *b*) and *N. Sieboldii* (XXXVIII. 32 *g*), and in the shorter conical elevations on the disk of *Synchæta* and *Polyarthra*, and in the horns of the last-named genus.

A further departure from the highly-developed antennæ of some Rotatoria is exemplified in the fossæ, pits, or apparent apertures (XXXVIII. 28–30), oftentimes with elevated edges, containing a tuft of bristles, which are met with usually on the necks of the animals. These fossæ, as well as the retractile and non-retractile antennæ of all forms, Leydig believes to be in immediate and special relation with nerves which extend to the base of the brush of rigid cilia. The number of such fossæ varies in different species. In accordance with his hypothesis of respiration, Ehrenberg called them "ciliated respiratory openings." In *Enteroplea* (XL. 2), *Hydatina* (XL. 1), *Diglena*, *Otoglena*, in *Euchlanis triquetra*, and in several *Notommatæ*, an apparent aperture exists on the neck. More than two are seen in *Polyarthra*, *Notommata Myrmeleo*, and in *N. Sieboldii* (XXXVIII. 29), arranged along the back; and in *Asplanchna Brightwellii* (Gosse), Dalrymple met with two on the back, which he supposed to be and described as lateral apertures, but which, Leydig affirms, have the unbroken cuticle lining them (XXXVI. 9).

Interesting variations are found in *Noteus*, in which Ehrenberg describes a short, stout, respiratory tube, or, as it actually is, a depression surmounted by a very elevated margin. In *Notommata centrura* (XXXVIII. 26 *b*), and in *N. Copeus*, a long seta projects from a small elevation of the cuticle, on each side of the back, having its extremity divided like a brush. The doubtful ciliated depression conceived by Prof. Huxley to be the nervous centre, belongs, in Leydig's opinion, to the category of tactile fossæ.

Appendages of the Trunk.—The account already given of the cuticle and lorica and their processes, leaves no special appendages of the trunk to be described. Thus we have spoken of the spines from the anterior and posterior margins of the lorica, of those which, in a few examples, are produced from its surface, and of the setæ or cirrhi which extend from it in *Anuræa biremis*, in *Notommata Copeus*, and, on a larger scale, in *Triarthra* and *Polyarthra* (XXXVIII. 30 *c*).

The *pseudopodium*, or false foot, may either be accounted a production or appendage of the trunk, or a distinct segment of the body. Its dimensions and figure vary much in different species; and in several it is entirely absent. It attains the highest development in *Philodinæa* (XXXVIII. 1, 2), where it consists of several progressively diminishing segments united by sliding joints, like the tubes of a telescope, and is analogous to the tails of many Entomostraca, *e. g.* the *Cyclopidæ*. In this family, *Philodinæa*, the body tapers into the pseudopodium by a gradual lessening of the articulated segments; so that the termination of the trunk proper and the commencement of the process have no external indication, except what is supplied by the anal orifice of the alimentary canal, which usually opens at the base of the tail. In other families the termination of the trunk is more abrupt, and the distinctness of the pseudopodium as a subordinate segment or member strongly pronounced (XXXVIII. 25, 26). The high development of the organ gradually diminishes, until the telescopic-jointed foot-process is degraded to the condition of one or two stiff styles, supported on an enlarged base (XXXVIII. 22), the intermediate stages being represented in various species (XXXVIII. 23, 24, 25, 31). In *Brachionus*, *Colurus*, *Stephanops*, and *Dinocharis* the foot-process, although of three or more telescopic joints, is of much smaller diameter, and depends like an appendage from the trunk, and is a transition between this form and the usually tapering figure of the *Philodinæa*, as seen in *Rotifer macrurus*, the trunk of which is abruptly attenuated into a long foot. A further reduction of the many-jointed telescopic pseudopodium to one or two joints, terminated by a single, double, or triple styliform or pincer process, is exemplified in many *Notommatæ* (XXXVIII. 26), in *Cycloglena*, *Lepadella*, *Metopidia*, *Salpina*, *Diglena*, *Eosphora*, *Hydatina* (XL. 1), *Ratulus*, &c., where the articulate structure is reduced to the condition of an appendage of the trunk, its terminations assuming the chief importance. Indeed, in some cases, one or two styliform processes seem to be produced immediately from the trunk without the intervention of an articulated segment at the base (XXXIX. 1–3). At the same time a styliform foot-process is, as a rule, a very short pseudopodium supporting one or more long styles. In the case of the less-developed or perfect tail-processes, the section of the body is frequently attached obliquely to the trunk.

In a very few examples the posterior dorsal surface of the body is prolonged as a true tail, having the pseudopodium fixed in front of it, the anal orifice being between them. This is witnessed in *Notommata Copeus* (XXXVIII. 26).

The pseudopodium has in some genera styliform processes attached to it throughout its length, as seen in the highly-developed telescopic prolongation of the *Philodinæa* (XXXVIII. 1), in *Callidina*, *Rotifer*, *Actinurus*, and *Philodina*, and also on the shorter foot-process of *Dinocharis*. These styles are moveable and flexible, and occur in a single pair or in two or three pairs; Ehrenberg gave to such, when short and not rigid, the name of '*toes*,' and distinguished the prolongation on each side of the posterior border of the sliding-joints, seen in *Rotifer*, *Actinurus*, and *Callidina*, as 'horn-like processes.' In *Scaridium* (XXXVIII. 22) and *Dinocharis*, the foot, though jointed, seems not to be retractile.

The pseudopodium differs much in its length and mode of termination. Where the articulated segments are few and small, the foot, if terminated by styles, oftentimes acquires a great length. In some species the terminal styles are three in number—*e. g. Actinurus*, *Philodina Neptunius*, *Dinocharis*, and in some *Stephanopes*; and more frequently the central style is shortest. Two terminal styles are more common. Illustrations are found in *Furcularia*, *Scaridium*, *Distemma*, &c. A foot ending in a pair of styles is said by Ehrenberg to be 'forked' (*furcate*).

In numerous species the styles have much rigidity, and are greatly elongated; in such instances they are known as styliform setæ, or simply '*setæ*.' Two such terminate the trunk in *Notommata longiseta*, *N. æqualis*, and in *N. Felis*—in the last-named they are also curved backwards,—whilst but one is produced from the body in *Monocerca* (XXXVIII. 399), *Mastigocerca* (XXXIV. 438–440), and in *Ratulus*; in the last, moreover, the base of the setæ is surrounded by stiff hairs.

Another very common termination of the foot is by a pair of short thick flaps, moveable on their base, and named 'pincers,' or 'pincer-like processes.' Such are seen in *Brachionus*, *Hydatina* (XL. 1), *Enteroplea* (XL. 2), *Diglena*, *Eosphora*, *Noteus* (XXXVIII. 25), and in several *Notommatæ* (XXXVIII. 5, 25, 26).

All the preceding varieties of the pseudopodium are modifications of the articulated telescopic type, and associated with a tolerably firm cuticle. But there is yet another type, in which no articulated segments occur, and which, from the softness of its tissues, is thrown into wrinkles or folds during contraction. Illustrations of this are found in all the urceolate genera of the Rotatoria, viz. in *Conochilus*, *Lacinularia*, *Melicerta*, *Tubicolaria*, *Stephanoceros* (XXXVIII. 1, 17, 19), &c., and, besides these, in the free *Megalotrochæa* (XXXII. 374–378) and in *Pterodina* (XXXV. 502–504). In the attached genera especially, this form of pseudopodium rather merits the name of '*pedicle*' or footstalk. In *Pterodina* the cylindrical foot-process is trumpet-shaped, and discoid at its free extremity, which is supposed to act like a sucker. A suctorial end to the pedicle is likewise presumed to exist in some or all of the fixed genera.

Cilia have been discovered on the extremity of the pseudopodium of *Pterodina* and *Tubicolaria*, and on that of *Megalotrocha*, *Lacinularia* (XXXVII. 10), and *Brachionus* in the young or immature state.

Lastly, a pseudopodium is absent in *Anuræa*, *Asplanchna* (XXXVI. 9; XXXVII. 29–32), *Polyarthra*, *Triarthra* (XXXVIII. 30), and *Ascomorpha*.

The observations of these and other particulars concerning the pseudopodium, its presence or absence, its structure, its length relatively to the body, and to its own processes, supplies valuable characters in the systematic distribution of the Rotatoria; and the details so derived furnish the fundamental divisions of the classification proposed by Leydig (*see* Classification).

The foot-like process is essentially a muscular organ; it contains no viscera, but in highly-developed forms some small bodies supposed to be glands, and in some examples certain vesicular spaces supposed by some to be ganglia, by others, vacuolar thickenings of the connective tissue (XXXVII. 17 *n*). The anus always opens at the base of this segment, and on its posterior aspect; hence it is that, though often called a tail, it is really not homologous with that appendage of higher animals; and consequently most writers prefer to name it pseudopodium, foot-process, or foot. It certainly has no evident resemblance to a foot, although anatomically it is a limb or member, and is functionally an organ of locomotion and of support. It is much less concerned with motion than the rotary organ, and, from its occasional absence, is evidently a non-essential organ. A principal purpose which it seems to answer is that of a rudder, steering the animal in its course like the tail of a fish. However, occasionally, when developed in a styliform manner, as in *Scaridium* (XXXIII. 423), it is a powerful and peculiar locomotive appendage, enabling the animal to leap. The pincer-like termination seems to enable the animals to hold fast to or grasp objects, or to push themselves forward. The short flexible toes developed on the pseudopodium, and the supposed discoid extremities, serve to attach the animal whilst the head may be moved freely about, or whilst it advances in a leech-like manner by the alternate forward movement of the head and foot.

Of the Muscular System and Movements of the Rotatoria. Muscular System.—In this class a muscular system, subservient to the functions of locomotion, nutrition, &c., is well developed; and, the integument being transparent, its structure and arrangement are distinctly visible. The muscles (XXXVI. 5; XXXVIII. 28 *a*) resemble fine lines, cords, or bands passing from one part to the other, and may generally be distinguished by being thickened during contraction, and attenuated by extension. All those attached to the walls of the body arise from the inner layer of the integument, which is thickened at the spot. They may be considered, with reference to their functions, to be of two kinds—the one concerned in the general movements of the body, the other in acting upon special organs or viscera. The first constitute two sets—the one annular, encompassing the body, the other longitudinal. The annular or transverse muscles (XXXIII. 5, 6 *t*; XXXVIII. 26 *v*) are separated from each other by considerable intervals; and to them is due, in many species, the apparent segmentation of the trunk. They are, so to speak, imbedded in the inner epidermic layer. Ehrenberg mistook them for vessels.

The longitudinal muscles are more numerous and definite (XXXVI. 5 *l*, 9 *l*; XXXVIII. 28 *a*; XL. 1 *m*). Mr. Williamson believes that delicate fibres occur in the thickness of the skin of the trunk, designed to shorten the animals by corrugating the surface. The long muscles extending from the posterior extremity of the body to the rotary organ and the maxillary bulb, and serving to retract those parts, are the most highly developed. Dr. Dobie describes muscular bands in *Floscularia*, passing up between the lobes of the ciliated head, and more delicate fibres along the centre of each lobe towards its extremity. The muscles of the tail (foot-process) are also numerous, large, and strong, and traceable to its terminal segments (XXXVI. 5 *b*; XXXVIII. 26 *n*) on the one side, and on the other as far forward as the anterior part of the body and the maxillary bulb. Williamson states that the fibres reaching the extremity of the foot-process are inserted into a little concavo-convex body found there. By its muscular apparatus the tail can be curved, moved from side to side, and shortened, and in a few examples, *e. g. Scaridium*, doubled beneath the belly. The counterforce, whereby the pseudopodium recovers its straight figure and position relative to the body, is the elasticity of the integument. Where the sliding joints exist, this elasticity must chiefly reside at the lines of junction, since the segments themselves have great rigidity, and do not admit of corrugation. However, the extension of this process much depends on the influx of fluid forced into it by a general transverse contraction of the body which is seen to precede it. The extension of the body, after having been shortened by the contraction of its longitudinal muscles, is chiefly due to the elasticity of its integument, which has an inherent tendency to constrict itself or to lessen its diameter. Prof. Williamson dissents from this explanation, believing the extension to be due to the circular muscular bands, as in the pseudopodia of the *Echinus* and starfish, or in the trunk of an earthworm. The shortening of the body is provided for by the sliding structure of its segments, and by the wrinkling (XL. 1) of its surface (XXXIX. 1–3), sometimes by both these modes together, at others by one alone. Even where its length is diminished by the formation of mere folds of the skin, those folds are constant in position and arrangement. Longitudinal folds pretty regularly disposed occur in the softer-skinned varieties—for instance, in various species of *Notommata* and *Hydatina*.

Muscles supplying special organs are seen in connection with the trochal disk, the maxillary head and jaws, the alimentary canal, and the reproductive apparatus (XXXIX. 7). Excepting the muscles moving the rotary organ, these will be best described in the account of the organs with which they are connected.

The trochal disk, and, indeed, the whole head supporting it, is constricted, corrugated, contracted, and moved from side to side by considerable muscles, extending from it to the maxillæ, and to the sides and posterior boundary of the abdominal cavity (XXXVIII. 28 *a*); special muscular threads act upon particular lobes, prominences, or processes which may extend from the head or its ciliated disk. In the trochal disk of *Melicerta*, Prof. Williamson detected interlacing threads which he supposed to be muscular; and Mr. Gosse has remarked in the same animal "a series of five or six annular threads set in the inner skin, which are probably muscular, and aid in the complex movements of the head." Some of the interlacing threads, which Ehrenberg described in several Rotatoria (as, for instance, in *Lacilunaria*), and which at one time he regarded as vascular, at another as a nervous or muscular network, probably were muscular, although most of them were merely fibres of connective tissue.

The extrusion of the head and trochal disk, after retraction, is principally effected, as in the case of the pseudopodium, by the elasticity of the integument, consentaneous with the relaxation of the muscular contraction,—this elasticity serving to unroll the involuted head and trochal disk, and to expand their parts, and, by its general operation on the body, to elongate the whole figure, and thereby press the contained fluid forward and backward against the retracted organs, so as to push them out. Prof. Williamson would also attribute the protrusion of the head to the action of the circular muscles, as he does not think there is sufficient proof of such elasticity independently of muscular fibres. The retracted head and appendages of the Bryozoa are thrust outward in a similar manner.

The cilia of the trochal disk have generally been assumed to be seated on a muscular mass, forming the cushion-like contractile thickenings on the head of the Rotatoria (XXXVI. 93). These structures display, according to Dujardin, no distinct muscular fibres; but in the opinion of others, such are present. Ehrenberg, as before stated, went so far as to imagine, not merely a network of muscular fibrils moving the entire apparatus, but also a series of four muscles at the base of each cilium moving it in every direction. Such an array of definite muscles to move an almost imperceptible organ, is not only entirely hypothetical, but most improbable. Leydig, on the other hand, opposes the idea of the muscular nature of the trochal disk, and regards it as consisting solely of the soft epidermic tissue, or, which is nearly the same thing, of connective tissue. Much discussion has arisen concerning the structural composition (*i. e.*, in a word, the histology) of the muscles of Rotatoria. Dujardin and Ecker questioned the existence of actual muscular fibres, but recognized a soft contractile substance, often drawn out into threads. The former, however, inclined to the belief in the existence of determinate muscles, although observation, when he wrote, had not made it certain. Thus, at p. 611, when describing a new species of *Floscularia*, he remarks that, "by gentle compression of the animal, five independent cords were brought into view, contractile and tolerably regular in outline, which perhaps ought to be called muscles; they extended through the pedicle and to the extremities of the lobes of the rotary organ."

Ehrenberg noted the presence of muscles in most Rotatoria, and in a few specimens believed he had detected transverse striation,—a fact which would establish an analogy between them and those of the highest animals. This highly-developed organization was denied by Siebold, who described the muscles to be of the non-striated variety so largely distributed among other Invertebrata as well as Vertebrata. But the belief now prevails, that the possession of transversely-striated muscles is one of the characteristics of the Rotatoria, although non-striated fibrils may likewise occur.

Leydig thus treats this subject:—"The element of muscle is the primitive cylinder, which is of two sorts—fine and thick,—the former in clear homogeneous threads, which, when traceable, are perceived to be branches of cells; such occurs principally in muscular networks; the latter—the thick primitive cylinder—originates from cells coalesced in rows, and it, therefore, presents internally, at considerable intervals, the still-remaining cell-nuclei. These cylinders exhibit a gradual advance in their further histological phases. They may remain homogeneous like the finest primitive cylinders, or resolve themselves into a homogeneous sheath, and an axial substance in the form of molecules. Lastly, the contents of the cylinder may break up into muscular (sarcous) particles, and therein approximate to the so-called transversely-striped muscles, to which at length it may attain a complete resemblance." Thus the cell-wall comes to form an investing sheath or sarcolemma of each fibre, and the cell-contents the vital contractile substance, or the sarcous particles. Leydig adds—"Both varieties of muscle, simple and striated, occur in the same species, so that the gradual transition of one into the other is unmistakeable." The existence of striated muscle has been noted by Ehrenberg in *Euchlanis triquetra*; by Oscar Schmidt in *Pterodina Patina*; by Perty in the foot of *Scaridium longicaudum*, in *Polyarthra* (XXXVIII. 30 *m*), in the marginal muscle of *Diglena lacustris*, and of *Brachionus tripos*; by Leydig in *Notommata Sieboldii* (XXXVII. 32 *a*) and *Noteus*; by Dalrymple, in *Notommata Anglica*; by Williamson and Gosse in *Melicerta*: and, without doubt, it may be discovered in most other genera (XXXIX. 7).

Perty has noticed in the foot of *Floscularia* rows of granules, and fine longitudinal striæ,—an intermediate condition referred to in the description of Leydig, given above. Bergmann and Leuckart mention in a note (p. 377) in their work, that in some animals transversely-striated muscles are visible. Prof. Williamson's observations support some of Leydig's views. "When one of these muscular fasciculi," writes the English naturalist, "is drawn out at full stretch, its surface is seen to be marked, at very regular intervals, by dark transverse bars (XXXVII. 18). Each fasciculus has a diameter of about $\frac{1}{3500}$th of an inch; and the transverse striæ recur at distances of about $\frac{1}{9000}$th. These intervals are rather larger than those seen in the fasciculi of human voluntary muscle. . . . On rupturing the fasciculi transversely, we perceive that each one is invested by a delicate sarcolemma. This is well seen at the upper part of the tail, where, on the contraction of the muscle, the non-elastic sarcolemma becomes corrugated, and only recovers its smooth aspect when the muscle becomes relaxed. These rugæ of the sarcolemma must not be confounded with the transverse striæ of the muscular fibre."

MOVEMENTS OF ROTATORIA.—These are very various; at the same time some varieties are so constant in several genera and species, as to furnish characters of much utility in the systematic distribution of the class. There are two principal modes of locomotion,—one by simple motion onwards, or swimming, with or without rotation of the body on its long axis (*e. g.* in *Brachionus*), the other, confined to the family *Philodinæa*, by crawling after the manner of leeches, each extremity of the body being alternately fixed. The latter mode of locomotion is partaken with the first, and the one or the other resorted to at the will of the animal.

The rotary organ is almost exclusively concerned in producing the uniform swimming movement and in turning the animal on itself, whilst the muscular tail acts as a rudder in directing the course. The trochal disk is worked with various degrees of energy and completeness; when in full action, the velocity attained is very great.

Usually the Rotatoria swim on the abdomen; but exceptions occur, as in *Eosphora Najas*, which, like the Phyllopoda, swims on its back. *Noteus* and a few others turn on their short axis, or, in common parlance, head over heels. Other exceptional modes of locomotion are met with in *Scaridium*, in *Triarthra*, and *Polyarthra* (XXXVIII. 30, 32), which have, besides the ordinary swimming movement, the power of leaping or skipping,—in the first, by means of the elongated styliform tail, which can be doubled under the body, and then suddenly relaxed like a spring; in the two last, by the aid of some rigid bristles, or cirrhi, attached to the body, and acting like the long legs of a flea. A skipping movement is likewise attributed by Ehrenberg to *Notommata longiseta*, due to its double, long, caudal styles, and an act of rowing, by means of a long lateral spine on each side, to *Anuræa biremis*.

The preceding remarks apply to the locomotive Rotatoria; but the encased species, although unable to change place, have, nevertheless, a considerable power of movement within and about their urceoli. They can extrude the greater part of their body, and bend themselves over the edge of their case, or withdraw themselves entirely within it. They owe this latitude of motion chiefly to their long pseudopodium or pedicle, which contracts by throwing itself into very numerous and deep wrinkles; for in none of the attached species is this organ articulated. In comparison with that of the pedicle, the capacity of the trunk of the animal to shorten or contract itself is but small, and its transverse folds few, distant, and collected, mostly towards the posterior extremity. The movements, in fine, of the urceolated Rotatoria are limited to those of extension, retraction, and flexion; and the extent to which they may be exercised is in direct proportion to the length of the pedicle. Nevertheless, when forcibly expelled from its case, which can easily be done without injury to the soft animal, the mature *Melicerta* swims about with considerable velocity by means of its ciliated rotary disk,—the peduncle being partially drawn up towards the body.

Although incapable of movement as individuals, a cluster of such as live in compound masses, *Conochilus* for instance, may float about freely, reminding us of the spheres of *Volvox*. The locomotive Rotifera also enjoy, in a considerable measure, the power of moving their own bodies,—thus frequently altering the relative positions of the various parts, and modifying their general form. Their rotary organ, as already seen, may be extruded or retracted within the body; the body itself may be extended at full length, or very much contracted on itself. So much may the whole animal be contracted, that, except by the detection of the characteristic Rotatorial organization, its nature would certainly be mistaken. An illustration of this is furnished in the figures of Dujardin and Perty (XXVIII. 4).

The mode of termination of the pseudopodium permits many of the Rotatoria to attach themselves at will to any object, some (*Pterodina*, for instance) assuming a fixed position for a long time together. When thus at rest, the rotary organ may be retracted or extended; in the latter case, although suspending its function as an organ of locomotion, it is in full operation as a respiratory organ, as well as serving to procure food. The body, moreover, is often in active motion when fixed by the extremity of the foot-process —oscillating from side to side, bending itself, and even turning as on a pivot.

The Digestive System.—The Rotatoria possess a distinct and undoubted alimentary canal, evident as a tube, traversing the interior, from a mouth to a posterior outlet or anus, composed of distinguishable parts with accessory organs. One group of the family is deficient of the anal outlet; and in male animals the digestive apparatus is atrophied or wanting.

The digestive tube is mostly straight throughout its course (XXXIX. 1; XL. 1); the exceptions to the rule occur with the encased genera, in which the intestine is curved on itself, and the anus advanced forwards to some spot beneath the head (XXXVII. 17 *i*).

The parts to be distinguished in the alimentary canal are—1st, the mouth or oral cavity; 2nd, the pharynx or vestibule (XXXVII. 19 *a*) between the 1st and 3rd, the œsophageal head (XXXVII. 19 *b*); 4, the stomach, with appendages (XXXVII. *c*, *d*); 5, the intestine with its outlet; and 6, the cloaca (XXXVII. *e*, *f*). Each and all of these parts present great diversity in figure, size, and accessory organs; but yet in nearly all forms the peculiar type of the digestive canal of Rotatoria is well marked.

The *mouth* is situated, as a rule, on the margin of the trochal disk, at the centre of its ventral aspect. Where the circlet of cilia is double, as in *Lacinularia* and *Melicerta* (XXXVIII. 21), the mouth, as we have already seen, is placed between the two rows; and in *Floscularia* and *Stephanoceros* it occupies the centre of the area formed by the ciliated apparatus of the head. The mouth is, moreover, subject to variations from the presence of appendages about it. Thus, in *Melicerta*, Prof. Williamson describes two small, projecting, "flattened lobes with ciliated margins, continuous with those of the 'chin,' which obviously assist in directing the food into the œsophagus." Leydig notices, in *Notommata Sieboldii*, a sort of upper lip, not ciliated; and Huxley, in *Lacinularia*, states that the mouth is vertically elongated, and its cavity expanded into "two lateral pouches, which give it an obcordate form; these lateral pouches contain the lateral ciliated arches that become lost below in the cilia of the pharynx." In *Floscularia* the cavity of the mouth is funnel-shaped (infundibuliform) (woodcut), and is termed by Dr. Dobie the "infundibulum," who describes the edge to be "frequently divided into lobes."

The mouth opens posteriorly into a canal, through which the food passes to reach the "œsophageal bulb." This canal has unfortunately received various names, viz. *œsophagus*, *pharynx*, *vestibule*, *infundibulum*, and "buccal funnel." The first term has likewise been applied to another tube intervening between the "*œsophageal head*" and the stomach; hence a looseness of nomenclature, tending to confusion and error in description. If, as is usually done, the name "*œsophageal bulb*" be given to the jaws and their muscular envelope, then that of œsophagus rightly belongs to the canal leading thence to the stomach. If, on the other hand, the "œsophageal bulb" be regarded as an accessory stomach containing a dental apparatus, as in the lobster, then the term œsophagus belongs to the tube extending between the mouth and the bulb. The following physiological distinction is, however, noted by Prof. Williamson, who says—"The stomach of the lobster, with its dental appendages, is that in which the digestive process is carried on. Such is never the case with the pharyngeal bulb of the Rotifera. The digestive sac is situate lower down. The pharyngeal bulb bears closer affinity to a gizzard, resembling that of *Bowerbankia* and other Bryozoa, differing, however, from that of a bird, which is located *below* the "proventriculus" or true stomach. However, some confusion will be removed by avoiding the term "*œsophagus*," and, without troubling ourselves with the precise homologies of the parts, by naming the tube between the mouth and jaws the "*pharynx*" or "*vestibule*," the jaws themselves with their surrounding mass the "*maxillary bulb*" or *mastax* (Gosse), and the canal between the last and the stomach the proventricular or gastric canal. The name "buccal funnel" has been imposed on the tube leading from the mouth to the maxillary apparatus by Mr. Gosse, and might advantageously have been adopted.

To proceed. The pharynx (XXXVII. 19 *a*; XL. 23 *m*) varies much in its dimensions: sometimes it is a narrow tapering tube, and, when contracted, visible only as a double line; at other times it is wide and short, and then especially deserves the name of "vestibule," since it ceases to be a canal. Several peculiarities in its structure occur in different genera,—the most remarkable in *Floscularia* and *Stephanoceros*. In the former genus, the oral cavity (infundibilum, Dobie) is separated from the pharynx by a rim armed by non-vibratile cilia; the pharynx itself is again subdivided by a fissured partition or diaphragm, into an upper space (vestibule), and a lower large and very dilatable cavity, called the "proventriculus" or "crop." The crop ends below in, or in some measure embraces, the maxillary bulb (see woodcuts, Part II.). A similar structure obtains in *Stephanoceros*.

In *Melicerta* Prof. Williamson observed, within the pharynx near its junction with the maxillary bulb, the ciliated lining membrane "to hang in several loose, vibratile, longitudinal folds;" and Prof. Huxley, in his account of *Lacinularia*, gives the subjoined summary of these folds and valvular partitions:—"A narrow pharynx leads horizontally backwards from the lower part of the buccal cavity, and becomes suddenly widened to enclose the pharyngeal bulb in which the teeth are set (XXXVII. 19 *a*). Where the buccal cavity meets the pharynx, a sharp line of demarcation exists. In *Melicerta* two curved lines are seen in a corresponding position, and evidently indicate two folds projecting upwards into the œsophagus (pharynx). In *Brachionus* these folds are stronger (XL. 1 *b*), while in *Stephanoceros* and *Floscularia* (XXXVII. 1 & 19) this partition between the pharynx and what may be called the crop is still more marked. From the inner margin of the aperture in the partition, two delicate membranes hang down into the cavity of the crop, which have a wavy motion; and it is to them, I think, that what Mr. Gosse describes as an appearance of 'water constantly percolating into the alimentary canal' is due. Dujardin had already noticed these 'vibrating membranes' in *Floscularia*."

Observers coincide in describing the cilia of the oral cavity to extend into and line the pharynx (XL. 23 *m*). The walls of this tube are so very dilatable, that bodies of very considerable size can traverse it to the maxillary apparatus. In the genera *Lacinularia*, *Melicerta*, *Brachionus*, *Noteus*, and *Tubicolaria*, close to the wall, or actually within its substance, as Leydig represents in *Noteus*, are two conspicuous structures, described by that author to be vesicular, and not improbably salivary glands (XXXVIII. 27 *l*). Mr. Huxley alludes to these structures in the ensuing account:—"On each side the pharynx is a yellowish horny-looking mass, which sometimes appears cordate, at others, more or less completely composed of two lobes. I believe its function is to give strength to the delicate walls of the pharynx, and that it is, therefore, to be considered a part of the horny skeleton."

The pharynx ends mostly below, and partially embraces the "*maxillary bulb*" or "*mastax*," which contains the maxillæ or jaws supporting the "teeth," and has its mass made up of nuclear cells and muscular fibres (XXXVIII. 26 *m*). In the living animal the bulb is almost constantly in motion, contracting and expanding itself in what some have called a "peristaltic" manner. This alternate and constant movement, visible even in the embryo before escaping from the egg, was mistaken by Bory St. Vincent, and other of the older microscopists, for the pulsating action of a heart. The apparatus, however, is rather comparable to the gizzard of birds, or to the tooth-crushing mechanism in the stomach of lobsters and other Crustacea, though not, indeed, homologous with it. The "maxillary bulb" is bulky, more or less globose, with a prevailing tendency to a triangular figure with rounded angles (XL. 20, 23, 24). Sometimes it is oval or ovoid, and still more commonly heart-shaped, from being notched or furrowed on one side, indicating a bilobed structure. In *Melicerta* Mr. Gosse figures and describes a third lobe, below the usual "two globose bodies (or rather the bilobed single mass), equally hyaline and probably muscular, which seems united to the two others, and alters in form as they and the jaws work, lengthening downward as they approach, and dilating and shortening as they recede" (XXXVII. 23).

The mass of the "maxillary bulb" surrounding the maxillæ has been generally assumed to be muscular, and, as such, actively concerned in working the contained jaws. Gosse calls it a "muscular sac," and has even attempted the description of its component muscular bands. Leydig has represented the jaws to be acted on by exquisitely striated muscles (XXVII. 31). Prof. Williamson admits the existence of muscles affixed to the processes of the jaws, but states that the conglobate organ in which these are imbedded "is transparent, and composed of numerous large cells, each of which contains a beautiful nucleus with its nucleolus. The cells are only seen when the organ is ruptured between two plates of glass, when they readily separate from one other; but the nuclei, with their contained nucleoli, are distinctly visible in the living animal. Delicate muscular threads most probably penetrate this organ to reach the dental apparatus, though I have not yet detected them." Here a great discrepancy of opinion appears, between Mr. Williamson and Leydig and most other writers, respecting the constitution of the globose mass of the maxillary bulb, and such as only reiterated examination can remove.

Dr. Leydig asserts that the bulb is covered externally by a chitinous membrane, of the same nature as the cuticle, and that the existence of a like membrane in its interior, developed for a special end, constitutes the maxillæ and appendages, just as bristles and horny plates and processes are developed out of the external cuticle.

The maxillary apparatus, contained within the soft mass of the bulb, is visible without any preparation, but may, from its hardness, be detached by strongly compressing or crushing the animal. Although much denser than the soft tissues of the body, yet like them the dental apparatus disappears by decomposition. Ehrenberg having an enormous number of *Brachioni* in a vessel of water, evaporated the fluid, and having burnt the desiccated animals, examined their ashes chemically, convinced himself they contained much phosphate of lime, derived, as he supposed, from the maxillæ. Mr. Gosse likewise concludes that, from their great solidity and density, and from the action of menstrua upon them, they are of calcareous nature.

The construction of the jaws, and the number and position of the transverse bars or 'teeth,' afforded Ehrenberg characters of primary importance in the construction of his system; and he indicated three leading types, under which all the Rotatoria could be classed, viz.:—"1. *Agomphia*, toothless; 2. *Gymnogomphia*, free-toothed (unconnected); 3. *Desmogomphia*, connected or attached teeth. In *Gymnogomphia* the teeth are free in front, and, like the fingers, united behind by a common band—the jaw; in *Desmogomphia* they are attached transversely across the jaw-piece, like an arrow lies across the bow. In the former, again, the teeth in each jaw are single or several in number; in the latter, either two or many. Hence there are 5 groups:—1. Agomphia—e. g. *Ichthydium*, *Chætonotus*, *Enteroplea*; 2. Monogomphia (one-toothed)—*Pleurotrocha*, *Furcularia*, *Cycloglena*, *Monostyla*, *Lepadella*; 3. Polygomphia (many-toothed)—*Hydatina*, several *Notommatæ*, *Euchlanis*, *Stephanoceros*, *Brachionus*, &c.; 4. Zygogomphia (twin-toothed)—*Callidina*, *Rotifer*, *Actinurus*, *Philodina*, *Monolabis*, and *Pterodina*; 5. Lochogomphia (teeth set in rows)—*Ptygura*, *Megalotrocha*, *Melicerta*."

This classification of the Rotatoria, however, Ehrenberg confessed to be imperfect, as wanting repeated researches to fix on the truly generic and specific resemblances and differences of the dental apparatus. In fact, although the conditions may be constant in the same species, yet they are so minute, that they frequently can be made out very imperfectly and with uncertainty; and, besides this, the variations in the positions of the animal when moving its body *appear* so materially to alter the form of the mechanism in question, that careful students often differ respecting it in the case of the self-same animal. To illustrate these remarks, we may appeal to the description of *Melicerta ringens*, as separately and independently detailed by Prof. Williamson and by Mr. Gosse. The latter represents three or four transverse bars or teeth to each lateral jaw (XXXVII. 23), the former above a dozen (XXXVII. 26); the one detects a trilobed bulb, the other speaks of a single conglobate organ, but which, from his figures, might be called bilobed. Additional illustrations of such doubt and uncertainty are to be found on comparing the descriptions of the maxillary organs recounted by any two observers. Ehrenberg's representations are now set aside by all, improvements in the microscope, and repeated examinations, having demonstrated their erroneousness. The whole tribe of Agomphia or toothless Rotatoria must be set aside; for it seems a well-established rule, that no female of the class is deficient of dental organs, and the genera *Ichthydium* and *Chætonotus* cannot, as before shown, be retained in the class. *Enteroplea*, again, is in all probability a male animal, and *Cyphonautes* wants, according to Ehrenberg's plates, the characteristic organization of Rotatoria in all its details. But it would be useless to continue an analysis of the other types established by the Berlin Professor, the existence of any one of which, having the particulars of structure assigned to it, is not to be demonstrated. What is worse, we must confess to the absence of any one detailed account of the dental apparatus which can be received with implicit confidence in its accuracy; so greatly have the leading writers on the Rotatoria differed among themselves in describing the mechanism in question.

Dujardin distinguished the following parts in the maxillary apparatus:—the "*fulcrum*" or support, a single central piece with two articulated branches; the "*scapus*" or lateral branch ending in an articulated point, "*acies*," and itself single or multiple, which is the jaw properly so called. In most cases, says Siebold, the horny jaws consist of two bent, geniculate processes, an anterior and a posterior; the latter gives attachment to the muscles moving the apparatus, whilst one or several teeth are developed on the former. In some many-toothed Rotatoria, each jaw is provided with three horny arches (*e. g.* in *Philodina*, *Lacinularia*, and *Melicerta*). Two of these arches (*arcus superior et inferior*) are turned inwards, whilst the third (*arcus exterior*) is directed outwards. To the under arch the muscles of the jaw are attached, which move the other two arches, with their transverse teeth, against each other.

Williamson gives the following particular account of the grinding apparatus of *Melicerta*:—"The gastric teeth consist of two essential portions, a pair of strong crushing plates, which bruise the food, and various appendages affording leverage and facilitating the action of the muscles upon them. The crushers are two broad elongated plates (XXXVII. 26), each being about $\frac{1}{800}$th of an inch long, and separated from each other at the mesial line, near which they become much thickened. From each of these plates there proceed laterally numerous parallel bars, all of which are somewhat thickened at their inner extremities where they are attached to the plates, whilst at their opposite ends they are united with the others of the same side by a curved connecting bar (fig. 26), from the outer sides of which are given off various loops and processes. The three uppermost of these bars are the largest, the rest gradually diminishing in size and strength as we descend, the inferior ones being almost invisible. From the upper extremities of the two crushers there project upwards and backwards two slender prolongations united by a kind of double hinge-joint near their apex, where they not only play upon each other, but also on a third small central fixed point, lodged in a little conglobate cellular mass. Ehrenberg only describes three transverse bars on each side, which he regards as teeth. It is obvious that he has only noticed the three upper and larger pairs. It is equally evident that these transverse teeth, as he terms them, do *not* move upon the strong longitudinal plates, as he imagines, but are firmly united with them. Muscles are either attached to the divergent peripheral processes, or to the cellular mass in which these processes are imbedded, causing the entire apparatus to separate into two parts along the mesial line by means of the hinge joint, the so-called teeth merely transmitting the motor force to the two longitudinal plates. These latter appendages are thus made to play upon each other with great power, and act as efficient crushers, bruising the food before it passes into the stomach, as is the case with the gastric teeth of the Crustacea. From the above remarks it will be seen that, though in its construction the dental apparatus is more complex than is represented by Ehrenberg, in its mode of working it is less so."

Prof. Huxley, to quote another accurate English observer, has seen in *Lacinularia socialis*, as also in *Stephanoceros*, the "pharyngeal armature composed of four separate pieces (XXXVII. 30): two of these (which form the '*incus*' of Mr. Gosse) are elongated triangular prisms, applied together by their flat inner faces; the upper faces are rather concave, while the other faces are convex, and upon these the two other pieces (the mallei of Mr. Gosse) are articulated. These last are elongated, concave internally, convex externally, and present two clear spaces in their interior; from their inner surface a thin curved plate projects inwards. At its anterior extremity this plate is brownish, and divided into five or six hard teeth with slightly enlarged extremities. Posteriorly the divisions become less and less distinct, and the plate takes quite the appearance of the rest of the piece." This is essentially the same structure as that of the teeth of *Notommata* described by Mr. Dalrymple (*Phil. Trans.* 1849), and by Mr. Gosse (XXXVI. 6) (*T. M. S.* 1851), and very different from the stirrup-shaped "armature" represented by Ehrenberg and Dujardin in *Lacinularia*. Prof. Huxley notes, moreover, the omission of the two pieces constituting the "*incus*," in the description given of the apparatus by Leydig.

The last-named author has attempted no general description of the dental organs, and has, in the specific details, so briefly adverted to their structure, that he would seem to attach to them little importance. He has, however, figured the maxillæ of *Notommata Sieboldii* (XXXVII. 31), wishing especially to represent the transversely-striated muscles acting upon them. He mentions the maxillæ, which occupy the spacious angular maxillary bulb, as exhibiting a bifid or forked portion, hooked at the ends, with a spine projecting from the inner side, and a margin on the outer side: to the latter the strong muscles for opening and shutting the maxillæ are affixed. The transverse striation of the muscles is particularly brought into view by pressure on the apparatus. Cohn (*Zeitschr.* 1855) has some very precise details respecting the structure of the dental mechanism of *Hydatina senta*, and of two or three other Rotatoria; but it would lead us beyond our scope, to transfer them to our pages.

The most elaborate attempt to unfold the true structure of the maxillæ, and to reduce all the varied forms to a common type the essentials of which are always detectable notwithstanding any degree of general modification, has been made by Mr. Gosse. The diversity of descriptions met with among writers on the Rotatoria, respecting the maxillæ, is materially due to the limited examination, undertaken by any one of them, of those organs,—each observer having studied some one, or at most but a few species, and then describing the peculiar maxillary organs met with as pervading the whole class: such as is essential to the discovery of their true relations, a comparison of their structure among all the genera, has been neglected. The right mode of study seems to have been undertaken by Mr. Gosse; but his conclusions require to be tested by repeated observation (*Phil. Trans.* 1855). His method of manipulation, for the purpose of examination, is well worth noting. He says (*op. cit.* p. 424),—"In the course of experiments with various chemical reagents on these animals, I found that a solution of potash had the effect of instantly dissolving the flesh and most of the viscera, leaving the general integument, the walls of the pharyngeal bulb, and all the solid parts of the manducatory apparatus uninjured. In most cases, also, the last-named organs are expelled from the visceral cavity by the contraction of the integuments, so that they float at large in brilliant clearness, undimmed by intervening tissues, and as patent to observation as when crushed between plates of glass, with the advantage of all the parts being unbroken and retaining their relative positions. Now, by turning the screw of the compressorium, flattening or deepening the drop of water, waves were communicated to it, by means of which the floating bulb, being nearly globular, was made to revolve irregularly, and thus to present, in succession, various aspects to the eye."

To display his researches ever so briefly, we must first introduce his nomenclature. The gizzard or enclosing maxillary bulb, he calls the *mastax* (XL. 20); and declares it to be a muscular trilobate sac. The *maxillæ* consist of two geniculate bodies (*mallei*) (XL. 20 *b*), and a third on which they work (*incus*) (XL. 20 *f*). Each *malleus* is of two parts—1, the *manubrium* (*c*), and 2, the *uncus* (*e*),—united by a hinge joint. The manubrium is a piece of irregular form, consisting of *carinæ* of solid matter, enclosing three areas, which are filled with a more membranous substance. The *uncus* consists of several slender pieces, more or less parallel, arranged like the teeth of a comb, or like the fingers of a hand.

The *incus* consists of two *rami* (*g*) articulated by a common base to the extremity of a thin rod (fulcrum) (*h*) in such a way that they can open and close by proper muscles. The fingers of each "uncus" rest upon the corresponding *ramus*, to which they are attached by an elastic ligament. The "mallei" are moved to and fro by distinct muscles; and by the action of these they approach and recede alternately, the "rami" opening and shutting simultaneously, with a movement derived partly from the action of the "mallei" and partly from their own proper muscles.

Under all the variations in form and disposition of the parts presented in *Euchlanis, Anuræa, Synchæta, Diglena* (XL. 24), *Polyarthra, Asplanchna, Monocerca*, &c., the same type prevails as in *Brachionus* (XL. 20–23) (which is the genus Mr. Gosse uses as his standard of comparison). The modifications in those genera may in general "be considered as successive degenerations of the 'mallei,' and augmentations of the incus. In another collection of genera (the fixed or urceolate), the organs, although essentially the same as in the former type, are somewhat disguised by the excessive dilatation of the 'mallei,' and by the soldering of the unci and rami together into two masses, each of which approaches in figure the quadrant of a sphere. The ascribed 'stirrup-shaped' armature of the *Philodinæa* arises from misapprehension; for it has no essential diversity from the common type, their analogy with the genera last mentioned being abundantly manifest, though they are still further disguised by the obsolescence of the 'manubria.' In *Floscularia* (XL. 25, 26) and *Stephanoceros* (XL. 27, 28) the most aberrant Rotatoria, the '*mastax*' is wanting; and in the former genus the incus and manubria are reduced to extreme evanescence, though the two-fingered unci show, in their structure, relative position, and action, the true analogy of these organs."

As to their homology, he argues they have no true affinity with the gastric teeth of the Crustacea, though he states his conviction that the Rotifera belong to the great Arthropodous division of animals.

"The action of the horny jaws," Mr. Gosse remarks in his account of *Melicerta*, "is not exactly that of two flat-surface mullers, working on each other in a grinding manner, but a complex motion impossible to be explained by words." Since the nature of our work has compelled us to limit ourselves to a mere outline of Mr. Gosse's most elaborate and important researches on the manducatory organs of the Rotifera, we cannot too strongly recommend the student to refer to that gentleman's essay in the *Transactions of the Royal Society*, both for a more complete acquaintance with his views and discoveries relative to those particular organs, and for a host of valuable details on other parts of the anatomy of this class of animals.

Some Rotatoria, the so-called single-toothed species, have the faculty of protruding their maxillæ beyond the mouth, and of using them, in this curious position, as prehensile organs. Thus the animal is enabled to seize upon prey without awaiting its being casually engulfed within the vortex of its ciliated head. Examples are found in *Synchæta mordax*, in *Distemma Forficula*, and in *Diglena* (XL. 24).

The maxillary bulb communicates immediately, or by the medium of a membranous canal, with the stomach—the next division of the alimentary tube. This canal is very commonly termed the œsophagus; but we prefer to call it the proventricular canal, to avoid confusion and doubtful analogies. It commences at the posterior inferior part of the bulb.

Leydig represents this tube to be lined by a continuation of the chitinous inner layer of the maxillary bulb, and uses this view to explain the distinctness of outline frequently remarkable in the walls when of considerable thickness, *e. g.* in *Notommata centrura* (XXXVIII. 26 *q*) and *N. tardigrada*. This sharp contour is especially manifest during contraction of the canal, whereby it is thrown into transverse folds or wrinkles, noticed by Ehrenberg under the title of "hard œsophageal folds," and elsewhere of a "rather firm framework at the commencement of the œsophagus." Leydig adds—"The organs described by Ehrenberg in *Notommata saccigera*, as 'large vibrating gills,' must, I think, be considered transverse folds of the chitin membrane in question." The existence of so dense a lining to the gastric tube implies the absence of cilia on its surface; and, in fact, Leydig declares he has never seen the least sign of such organs, although both Perty and Williamson affirm their existence. The folds into which this tube is thrown when contracted are occasionally (*e. g.* in *Notommata Sieboldii*) (XXXVII. 22) longitudinal instead of transverse. Mr. Gosse says of it that it is "composed of longitudinal and annular contractile tissue," and that, at least in *Asplanchna priodonta* (XXXVI. 9 *t*), "it is capable of immense dilatation, but commonly takes the form of a slender tube with the lower extremity swollen, where an oval pancreatic gland is attached on each side. The passage of a small morsel, such as a *Chilomonas*, shows that the walls of this organ are thick, leaving only a slender tube when corrugated." However, in different species the width and the thickness of its walls vary much. The proventricular canal has a considerable length in *Diglena* and *Synchæta*; it is rather long in *Triarthra*, *Lacinularia*, and *Hydatina*, and very short in *Euchlanidota*, *Brachionæa*, and *Melicerta*. In not a few genera it is altogether wanting, the maxillary bulb being superposed immediately upon the stomach: such are *Ascomorpha* and the genera of the family *Philodinæa*.

The *stomach* succeeds to the gastric canal as a distinct segment separated from the alimentary tube below by a constriction, and is remarkable also in general by its greater capacity (XL. 1 *e*). Leydig affirms that a portion of the digestive canal separated from the rest by a constriction, and essentially representing a stomach, exists in all true Rotatoria; but other writers describe, as in *Philodina* (XXXVIII. 1, 2), and in *Lindia* (XL. 1, 3), the existence of a straight, slender, funnel-like alimentary canal extending from the mouth to the cloaca without any constriction or any stomach dilatation. In *Hydatina* and *Synchæta*, Perty says the canal is uniform in calibre, without any stomach-like expansion; yet Cohn distinguishes the narrower lower end of the alimentary tube of *Hydatina* as an intestine, because it is less constantly occupied with food, is colourless, and, unlike the stomach, has no such cells on its wall. Moreover, as an irregularity, he twice met with a sphincter-like constriction (*pylorus*) separating the two. In *Euchlanis* and *Brachionus*, on the other hand, the division is clearly indicated (XXXIX. 16).

The opposing statements of authors on this question may probably be reconciled on the supposition that, of different observers, some have viewed the canal when it has been full and distended, others when empty and contracted, and that the constriction indicating a definite stomach has appeared only during repletion, just as happens with the human stomach, which, when full and engaged in digestion, is deeply constricted, and for the time appears almost like a double organ.

Ehrenberg distinguished four types of Rotatoria, according to the characters of the alimentary tube, which he respectively named—1. *Trachelogastrica*; 2. *Cœlogastrica*; 3. *Gasterodela*; 4. *Trachelocystica*.

1. The *Trachelogastrica* comprehended animals having a long filiform gullet,

rapidly transmitting and not retaining the food, and terminating in a comparatively short conical intestine, without a stomach dilatation, *e. g. Ichthydium, Chætonotus.*

2. *Cœlogastrica,* Rotatoria with a very short gullet, a long conical intestine, and no stomach, *e. g. Hydatina, Synchæta.*

3. *Gasterodela,* those Rotifers having an evidently developed stomach, or a dilatation of the alimentary canal limited by a definite constriction, *e. g. Euchlanis, Brachionus, Lepadella, Diglena,* &c.

4. *Trachelocystica,* with an indistinct gullet, but having a very long, filiform, small intestine, in which the food is detained, and also a large globular intestine (rectum or cloaca) placed close to the discharging orifice, *e. g. Rotifer, Actinurus, Philodina.*

Subsequent independent observers have been able neither to recognize all these distinct types of structure nor to admit their value. Leydig, in fact, insists that the so-called "gasterodelous" type is the only one seen in Rotatoria; but, as just now stated, several authors admit the existence of a simple conical or tapering alimentary tube, without dilatation or stomach, in several of the class.

The *Trachelogastrica* are represented only by beings which are now, by general consent, excluded from the Rotifera. The termination of the intestine in a dilated sac-like expansion, in which also the generative canals end, whence its name, "*cloaca,*" is the rule; or, to use Ehrenberg's term, the majority of the Rotatoria are *Trachelocystica.*

The stomach dilatation, like the rest of the alimentary canal, is capable of great expansion, by which its figure is considerably altered. Usually but one gastric cavity has been described; but in some species there is a second, and Huxley, in his history of *Lacinularia* (XXXVII. 19), describes three portions or divisions between the gastric canal and the rectum,—the first with two pyriform sacs opening into it, the middle one frequently with several short cellular cæca, and the lowest with several cellular cæca projecting externally, and clothed within with very long cilia. According to Prof. Williamson, the stomach of *Melicerta* (XXXVII. 17) consists of an upper and lower segment, separated the one from the other by a marked though varying constriction,—the upper stomach elongated, the lower almost spherical. Mr. Gosse describes this same organization in *Melicerta,* but calls the upper segment "a wide cylindrical stomach," and goes on to say that the food passes from this into a globose intestine which ends in a slender but dilatable rectum.

A similar double organ is found in *Floscularia, Stephanoceros* (XXXVII. 1 *f*), and *Tubicolaria.* Moreover Ehrenberg noted a sac attached to the stomach of *Megalotrocha,* which he called a cæcum. The configuration of the stomach is otherwise altered by tubular and saccular appendages, and in a few instances is lobular, as stated by Mr. Gosse in *Asplanchna* (XXXVI. 9 *s*). Ehrenberg states, at p. 399 of his great work, that the stomach of *Lacinularia* is complicated by two blind tubes (intestines), and yet, at p. 403, reverses this statement by saying that it is "without blind intestine-like appendices." Leydig admits the latter as the truth; but, as already seen, Huxley remarked two pyriform sacs attached to the first, and cæca to each of the other two segments. Ehrenberg further describes cæcal appendages to the stomach of *Notommata clavulata,* and of *Diglena lacustris,* but such were probably the turgid stomach-cells presently noticed.

The tissues or histological elements entering into the formation of the stomach are—1, a limiting external membrane, and, 2, an internal layer of epithelium (XL. 4). The former is the same tissue with that constituting the walls of other portions of the alimentary canal, and is supposed by many to contain muscular fibrillæ, although so very thin, pellucid, and apparently structureless. Leydig, however, calls it a homogeneous connective tissue. The lining of epithelium is made up of large turgid cells, rendering the wall thick and of a pulpy appearance (XXXVIII. 26 *f*). In young animals the epithelial cells are colourless; but in adult beings their granular contents are coloured and interspersed with fat-globules, whence it is that the walls of the stomachs assume a yellowish hue often intermingled with green and brown tints. The cells, moreover, commonly possess a nucleus and a nucleolus, and their free surface is constantly ciliated. They are readily detached from the subjacent membrane and from each other, and are then seen to have a spherical or ovoid figure.

"The great thickness of the epithelial layer," writes Mr. Williamson, "as compared with the entire diameter of the organ, is curious: whilst the latter averages about $\frac{1}{250}$th of an inch, the former is often not less than $\frac{1}{150}$th, or $\frac{1}{6}$th of its entire diameter. The cells, when detached, vary in size, from a diameter of $\frac{1}{1000}$th to $\frac{1}{6000}$th of an inch; one of these was fringed with cilia $\frac{1}{1600}$th of an inch long, and had a nucleus $\frac{1}{7000}$th of an inch. After being detached, some of the ciliated cells floated slowly away, like so many animalcules."

Although this description and the measurements refer specially to the *Melicerta ringens*, yet the relatively large size of the cells is a feature common to all the Rotatoria, and has been pointed out and figured by Leydig, Siebold, and others.

The second stomach, noticed by Williamson in *Melicerta*, also had a layer of epithelial cells bearing cilia "even longer than those of the upper viscus, —although the parietes were very much thinner and more transparent, the cells being less easily traced." In the third or lowest dilatation, seen by Huxley in *Lacinularia*, the interior was clothed with very long cilia (XL. 4).

Ehrenberg remarked the existence of large stomach-cells in *Diglena lacustris*, and of less distinct ones in *Notommata Myrmeleo* and *N. Copeus*. The pouches he speaks of around the alimentary tube of *Hydatina senta*, and which imparted the appearance, to his eye, of a bunch of grapes, are no other than epithelial cells. In *Philodinæa* the intestinal canal is stated to be filiform, and enveloped in a granular cellular mass; that is to say, the calibre is very much reduced by the turgid cells lining the walls. The compact mass of blind tubules, so described in Rotifer, admits a like interpretation.

In *Notommata tardigrada* Leydig failed to detect cilia either in the stomach or intestine.

In the great majority of the Rotatoria a definite "*intestine*" follows the stomach, and ends below in the cloaca. This intestine is generally known as the "*rectum*," and is supposed to represent the large intestine of higher animals. It varies much in its dimensions in different species, especially in its length and course. It is long, straight, and capacious in *Notommata centrura* (XXXVIII. 26), and in *Euchlanis triquetra* (XXXVIII. 5), short in *Lacinularia*, and extremely short in *Notommata tardigrada*.

Among the encased Rotatoria it is of considerable length, owing to its curving forwards from the second stomach, so as to reach its outlet near the margin of the enclosing urceolus, or in other words the neck of the animal, and thereby provide for the immediate removal of the excrementitious matter from contiguity with it (XXXVII. 17). In *Stephanoceros* and *Floscularia*, as exceptions to this rule, this intestine is short. Looking at the so-called second stomach, placed at the head of the rectum in these fixed Rotifers, we might rather assimilate it to the cæcum, which in some of the higher classes forms a sort of subsidiary stomach, where the digestive process is finally completed. Still it is not possible to establish all the minute homological relations between these animals and those of the vertebrate class. The intestine, like the stomach, has a limiting membrane, possibly muscular, and is lined by a ciliated epithelium which, unlike that of the stomach, is not coloured, and its cells less easily detected. It is capable of very great distension. The rectum commonly ends in, or, it may be said, expands into, a globular sac, which, from its likewise receiving the eggs from the oviducts opening into it, is analogous to the cloaca of birds (XXXVIII. 26 *i*). This cloaca has a fine, transparent wall, and opens, posteriorly or dorsally, at the base of the pseudopodium, or, where this segment is absent, near the extremity of the body, by an outlet usually called the anus.

The cloaca is particularly dilatable; for sometimes it is much loaded with accumulated fæcal matter, and at others is distended by one or more of the enormous eggs the Rotatoria habitually produce. In discharging an egg, or in emptying itself of other matters, the cloaca is everted and thrust out through its external orifice.

From the mode in which the walls are drawn into longitudinal and circular folds, as exemplified in *Notommata centrura* (XXXVIII. 26), Leydig is induced to admit the presence of muscular fibrils regularly disposed in the two corresponding directions. Moreover the manner in which the cloacal orifice is closed, after the extrusion of any mass, indicates, in this author's opinion, a sphincter power, and consequently the presence of muscular fibres around it. The contraction of the entire canal on itself is sometimes so great that it is only manifest by a streak.

A most remarkable structural exception is met with among certain female Rotatoria, viz. the entire absence of an intestine and anus. It prevails in the genus *Asplanchna* (Gosse), in the *Notommata Sieboldii* (Leydig) (probably in *N. Syrinx*), in *Ascomorpha Helvetica* (Perty), and in *A. Germanica* (Perty) (XXXVI. 9; XXXVII. 32; XXXVIII. 28). This want of a discharging posterior outlet necessitates the rejection of excrementitious matters from the stomach through the mouth.

This structure is so very exceptional and peculiar, that Prof. Williamson is not prepared, without further evidence than has yet been advanced, to admit it as true of any Rotifera. It is, he writes (*in lit.*) contrary to probability, and, if established, would induce him to exclude the animals so organized from that class.

Reception of Food—its Deglutition, &c.—The food of the Rotatoria, as before noticed, is attracted towards the mouth by the vortex caused by the rotation of the cilia crowning the head. An exceptional means of prehension is seen in those Rotatoria which protrude their jaws beyond the mouth, using them as pincers or forceps to seize any larger prey. "In general," writes Mr. Gosse (*Phil. Trans.* 1856, p. 429), "the ciliary vortices are sufficient to bring the prey within the buccal funnel (pharynx); but in several genera of the family *Euchlanidota*, as *Metopidia*, *Colurus*, *Monura*, and *Stephanops*, there is a curious accessory organ, which aids in the capture of the prey; at least I am sure it is so employed in several species of *Metopidia*. Thus in *M. acuminata* the frontal region is formed by an arched fleshy process occipitally, which is approached by a small one on the 'mental' side; and between these is the wide entrance of the buccal funnel. The occipital process is protected by a horny crystalline plate, forming a segment of a sphere, and, when viewed laterally, taking the appearance of a curved horn. It can be partially protruded and retracted, and also bent down to meet the mental lobe. This apparatus, when the animal is taking food, is kept in vigorous action. A strong vortex is produced by the ciliary wheels; and as the floating atoms whirl by, the moveable plate is thrown forward with a grasping motion, the fleshy head being at the same time protruded, and, when the lobes are in contact, retracted. This is repeated almost every instant with manifest eagerness and discrimination, the manducatory apparatus working vigorously all the while.

"The same curious organ is frequently employed in another way. It is bent considerably downward; and as the animal crawls deliberately up and down the stems of aquatic plants, it is used to rake and grub, among the floccose deposits, the minute *Diatomaceæ*, &c., that adhere to them."

Having entered the mouth, it is usually rapidly conveyed along the pharynx to the jaws. In those species which have the pharynx expanded into a "crop," such as *Floscularia* and *Asplancha*, this transmission of the food is less speedy. Mr. Gosse imagines the "crop" to possess a suctorial power. He says—"I think that when the animal (*Asplanchna priodonta*) is cognizant of food brought to the mouth by the ciliary vortices, it suddenly expands the crop by the action of the muscles that go from it to the skin, when the water rushing into the vacuum carries in the prey. Then the network of fibres contracts again, and the prey is secured."

Having reached the "maxillary head," the food is "lodged" (to quote Mr. Gosse's paper) "upon the '*rami*' between the two 'unci.' These conjointly work upon the food, which passes on towards the tips of the 'rami,' and enters the œsophagus (the proventricular tube), which opens immediately beneath them."

Having escaped the mandibular apparatus, the food is subjected to the action of some digestive fluids which are poured into the portion of the alimentary tube below, whether that portion be dilated into a distinct stomach, or retain a nearly uniform calibre. How long this process of digestion need be continued, we have no data to determine; but we may conclude that the time will vary according to the nature of the food, the condition of the animal, its species, and other circumstances. In *Melicerta ringens*, which has a double stomach, Prof. Williamson remarks that the upper one "appears to be chiefly a receptacle for the food. From time to time, especially when the viscus is distended, a portion of its contents pass down into the lower stomach." In this the mass of food usually distending it "is constantly revolving,—the motion being due to ciliary action. This process goes on for some minutes, after which the creature contracts its body, and forces the entire exuviæ out of the viscus into a long narrow cloaca (rectum), which terminates externally by an anal outlet. As it does this, it everts a considerable portion of the cloaca, thus almost bringing the cloacal outlet of the stomach to the exterior, and causing, at the same time, a large transparent protuberance to be developed on the corresponding side of its body. At other times the creature can draw in these appendages, so that scarcely any trace of a cloacal canal is visible." Mr. Gosse suggests that this protrusion, at the moment of discharge, is designed "to shoot the fæcal mass out of the case" (urceolus); for the outlet is then projected above the rim. "The fæces," he adds, "are slightly coherent and jelly-like, not at all like the coloured pellets of which the urceolus is built up."

The food of the Rotatoria consists of the lower Algæ, of Protozoa, Entomostraca, other Rotifers, and even the weaker members of the same species. "The stomach," remarks Mr. Gosse, "of the *Asplanchna* is frequently occupied with animals; the smaller *Anuræa*, as *A. aculeata*, *A. curvicornis* (?), and *A. stipitata* (?), seem to constitute its chief food. I have taken one with the species last-named in its stomach, which, after about an hour, was ejected and swam about as lively and apparently uninjured as ever. In one I saw several specimens of a long slender Fragilaria *loose in the cavity of the body*, and in the stomach of another the long cell of a Conferva."

From the manner in which the food is obtained, apparently without any selection on the part of the animals, the vortex driving into the mouth whatever particles may come within its reach, we might conclude that the contents of the stomach must be of a very miscellaneous character. This is true to a great extent; yet the Rotifers can eject what is unsuitable, and they have the power of moving from place to place in search of suitable nutriment, or at least, as in the fixed forms, of arresting and withdrawing the ciliary apparatus until noxious materials are floated past, or appropriate ones have come within reach. That they are passive recipients of the current setting into their mouths, is indicated by their swallowing carmine or other colouring matters mixed with the water, which, as Mr. Gosse observes, are deleterious to them.

The feeding of Rotatoria with colouring matter serves a practical purpose in the examination of their structure; for it helps to reveal, by the contrast of coloured with uncoloured parts, details of structure not apparent amid the uniform and delicate hue of the entire organism in its natural state. For example, Mr. Gosse writes—"The process of swallowing carmine enabled me to see (in *Melicerta*), very distinctly, that the œsophagus enters the gizzard between the larger ends of the jaw-mullers, and that the stomach-duct leads off from their smaller ends through the semiglobular lobe beneath." The same observer employed this means to demonstrate the manner in which the case of the *Melicerta* is deposited, and with very satisfactory results (see p. 425).

THE SECRETING SYSTEM.—Special organs of secretion exhibit themselves in the Rotatoria under the simplest form of cells, and of involutions of the lining membrane of the alimentary tube, as sacs and tubules. Frequently their contents are coloured; and these always differ in density and physical appearance from the general fluids of the body. The glandular organs situated about the walls of the digestive canal, are supposed to have discharging ducts through which their contents percolate into that tube.

The testes or spermatic glands in the male, and the ovary in the female—both of them secreting organs,—together with some accessory secerning vesicles, will be described under the section on the Reproductive Organs. Something has already been said of some other glands in the last section, on the Digestive Organs: a more precise account is, however, necessary.

The most constant glands are the two situated on the upper surface of the stomach near the entrance of the gastric or proventricular tube, and sometimes on that tube itself (XXXVIII. 26 *h*, 27 *l*). They are usually hemispherical or oval, but assume other shapes, as pyriform, conical, cylindrical, reniform, crescentic, and forked. In a few, *e. g. Noteus* and some *Brachionæa*, they are stalked, or, more properly speaking, have an elongated, tapering extremity. Cylindrical or club-shaped glands are seen in *Notommata clavulata*, and forked ones in *Diglena lacustris*. In these two species, and also in *Megalotrocha* there are likewise four long filiform tubes, equalling the glands in length, and of the like colour, but opening at the centre instead of the forepart of the stomach. In *Polyarthra*, Leydig noticed two elongated secreting-sacs attached to the *posterior* surface, and in *Lacinularia*, a pair of glands, instead of a single one, at the fore part of the stomach. Not being able to detect the ducts of the "2–3 pyriform glandular (?) -looking bodies often attached to the *base* of the upper stomach (of *Melicerta*) near the constriction which separates it from the lower one, Prof. Williamson hesitates to call them glands, and doubts likewise the secretory character of the similar but larger bodies seen in the neighbourhood of the œsophagus."

The glands are usually transparent, or have only a slight milky opacity; they contain fine nucleated granules and molecules, and in some examples, *e. g. Polyarthra* (XXXVIII. 39) and *Pterodina*, a few small oil vesicles. Externally they are invested by a transparent homogeneous membrane, to which, in *Albertia*, Dujardin assigned an active contractility; but this is very doubtful. "They are," says the French naturalist, "stalked sacs, placed at the commencement of the intestine, susceptible of contraction, pouring out their secretion into the intestine, from which they again fill themselves, and undergo dilatation: in this example at least, these appendages must be considered cæca rather than glands." "Sometimes," Leydig observes, "the elements of the contained granular mass have an elongated figure, as in *Noteus*; and then the contents of the glands assume a striated appearance." This account recalls that given by Mr. Williamson of a glandular structure he supposes may possibly represent a spermatic gland; but of this hereafter. Cohn believes he detected the exudation of a blackish granular fluid from these glands in *Hydatina senta*, and its entrance within the stomach by a definite aperture.

The granular vesicles of the glands were termed "vacuoles" by Dujardin, and have been represented by Ehrenberg in many figures, *e. g.* of *Euchlanis macrura*, *E. dilatata*, *Megalotrocha*, and *Lacinularia*; they have also been spoken of by him as "glands, vesicular within." Moreover the sharply-defined clear vesicles he has represented in *Theorus* (XXXIV. 427–429) and *Pterodina*, and termed "eyes," Leydig believes to be nothing else than fat-vesicles of the gastric glands. Mr. Dalrymple has accurately figured these glands in his so-called *Notommata* (*Asplanchna*) *Anglica* (XXXVI. 9 *g*).

The function and homologies of these gastric glands are doubtful. Ehrenberg's first notion of them was that they were spermatic; but he subsequently changed his views, and called them "pancreatic." "For what reason," says Prof. Rymer Jones, "Ehrenberg has given the name of pancreas to these secreting cæca, it is difficult to conjecture, since the first rudiments of a pancreas are only met with in animals far higher in the scale of animal existence; every analogy, indeed, would lead us to denominate these cæca the first rudiments of a liver, by far the most important and universal of the glandular organs subservient to digestion, and in a variety of creatures presenting an equal simplicity of structure."

However unsupported the notion of the pancreatic or salivary nature of these glands may be, it has met with several advocates, who have in all probability assigned to them this function rather from the want on their part of any definite opinion of their character than for any other reason. Thus Dalrymple alludes to them as salivary glands; and Perty affirms of two filiform vessel-like appendices of the stomach (?) in *Enteroplea*, that they are representatives of the pancreas or of salivary glands. Siebold adopted a similar hypothesis; but Leydig, on the contrary, regards them, in a morphological point of view, not as pancreatic glands, but as the analogues of those processes often seen on the stomach of *Arthropoda*; he would therefore designate them generally gastric glands,—a view with which we are disposed to coincide. The small glandular appendages on the dorsal surface of the stomachs of starfish, suggest themselves as of the same nature as the appendages under consideration.

A yellowish clear body is situated on each side of the pharynx, immediately in front of the maxillary bulb, in *Lacinularia*, *Tubicolaria*, *Melicerta*, and *Brachionus* (XXXIX. 16), and rather within the substance of the bulb in *Noteus*. This is possibly the structure alluded to by Mr. Gosse as "several yellow glandular (?) spots" seated on the top of the cushion of the dental organs of *Asplanchna* (XXXVIII. 28), and the same with the yellowish, clear, horny-looking masses mentioned by Huxley in *Lacinularia* (XXXVII. 19 *g*) and *Brachionus*. The last-named naturalist refers these bodies to the "horny skeleton" (see p. 412). Leydig considered they might possibly be "salivary glands."

The epithelium of the alimentary canal has probably a glandular purpose: its large cells are filled with a granular matter, and many oil-vesicles, besides a nucleus. The number and large size of these gastric cells have been already illustrated (see p. 419); they are mostly coloured—yellow or yellowish brown, with sometimes green spots interspersed. Ehrenberg remarked these cellular accumulations, and advanced the hypothesis of their homology with the liver of higher animals. The colouring matter was consequently esteemed to be the bile. We have seen that Rymer Jones has assigned the functions of a liver to the so-called "pancreatic" sacs, or "gastric glands." However, most naturalists favour Ehrenberg's view; among them are Dujardin, Siebold, Leydig, and Dalrymple. The belief, indeed, of the great Berlin naturalist was, that the cells grew from the exterior of the wall of the alimentary canal, and were so many saccular appendages; this view modern research does not countenance, but affirms the presence of the cells within the canal. The examples of secerning cells given by Ehrenberg deserve to be mentioned. He remarked that in *Enteroplea* the biliary cells and ducts were most pronounced, and that there was great accumulation of cellular or glandular elements about the intestine of *Rotifer*, *Callidina*, and *Philodina*; in the last two he also asserted that the mass becomes coloured by colouring particles swallowed by the animals.

Mr. Gosse puts the question whether the little granular body near the tip of the pedicle of *Melicerta* is a secerning gland for the secretion of an adhesive glue, by which the foot adheres, as in *Monocerca*. This faculty of secreting an adhesive matter from the end of the pseudopodium is surmised by Perty to be possessed by several Rotatoria, viz. by *Conochilus*, *Lacinularia*, *Œcistes*, *Floscularia*, *Limnias*, *Tubicolaria*, and *Stephanoceros*. This idea is countenanced by Cohn (*Zeitschr.* 1855, p. 439), who inclines to the belief that the solid-looking elongated-oval bodies situated at the posterior extremity of the abdomen of *Brachionus* and other species, and usually considered muscular (moving the tail-process), are rather of a glandular nature, and possibly secrete an adhesive glue to fix the animal. More recently (Müller's *Archiv*, 1857, and *A. N. H.* 1857, xx. p. 292) Leydig has accepted this view, and thus treats of these structures in *Hydatina senta*:—"The clavate bodies in the tail consist of a delicate envelope and pale molecular contents, in which beautiful nuclei, each with a nucleolus, may be distinguished; in many individuals, small fatty points are also present in variable amount. I regard the organs in question as glands, which in their position and function correspond with the caudal glands of *Enoplus* for example; they open at the apex of the caudal appendages (*Fusszangen*); and as the worm just mentioned 'can attach itself firmly to the object-bearer by the posterior extremity of the body, in order to carry the body round this point with a waving motion,' so also can the *Hydatina* fix itself by the tips of the caudal appendages, probably by means of the sticky substance excreted here. It seems to me also, that in a certain upright position of the caudal appendages, I have detected the opening at their tip."

Other large vesicles, which some think may be glandular, occur in different parts of the body, and in the foot-process of several genera. Such are noticed by Dobie in the pseudopodium of *Floscularia*; and Leydig mentions a clear gland or space at the root of the tail of *Lacinularia*, from which he supposes a duct to extend to the extremity; such a structure Huxley cannot discover, but states that the extremity of the tail always seemed to him "to present a ciliated hemispherical cavity, closed above;" the supposed gland at the base he called a "vascular mass."

An active secreting power is displayed by those Rotatoria which invest themselves in cases or urceoli; for such cases are always produced from the animal, and are the result of excretion. The formation of its case by the *Melicerta ringens* has often been most thoroughly examined; and Mr. Gosse was enabled to watch the deposition of pellet by pellet of the excreted matter. This direct observation has entirely overthrown the prevalent notion first advanced by Ehrenberg, that the case was built up of excrementitious particles discharged from the alimentary canal. The organ actively engaged in the building of the case is seated immediately above the long tubular process extending from the neck of the animal (XXXVI. 1 *c*); it is cup-shaped, and its concave surface so ciliated, that when in full activity it seems to revolve. In this, which Mr. Gosse calls the "*pellet-cup*," the building-material seems to be prepared and fashioned into an oval or hexagonal figure, and then the pellets so moulded are regularly laid down in rows, "straight and uninterrupted perpendicularly," but zigzag transversely, so that a diagonal disposition is the result. "Each pellet, examined separately, is of a yellowish or olive colour, composed of granules; the whole tube is of a reddish-brown (XXXVI. 1 *d*). After a certain number were deposited in one part, the animal would suddenly turn itself round in its case, and deposit some in another part." It seems that the action of the pellet-cup is voluntary, and not always coexistent with the passing of the ciliary current over the chin. The animal frequently makes abortive efforts to deposit a pellet, and sometimes bends forcibly forward to the edge of the case before the pellet is half formed. Coloured particles in the water are hurled round the margin of the ciliated disk until they pass off in front through the great sinus between the large petals; and the atoms, if few, glide along the facial surface, following the irregularities of the outline with great precision, and, dashing round the projecting chin, lodge themselves one after another in the little cup-like receptacle beneath, in which they are whorled round with great rapidity, and prepared into pellets for the construction of the case. On mixing carmine with the water, the torrent that poured off in front and the appearance of a rich crimson pellet in the cup were instantaneous. A large animal which had its case accidentally slit for some distance, watched for several days, was seen to make pellets frequently; yet it never deposited them nor attempted to construct a new case, but let the pellets float away."

Such is a *résumé* of Mr. Gosse's interesting observations. Prof. Williamson adds that, when the animal is not engaged in its architectural occupations, the sac (pellet-cup) becomes so contracted as to be almost invisible.

In connection with this subject of secretion, must be mentioned the views of Leydig respecting the accumulation of granules or crystalline particles seen in many embryonic and young Rotatoria, enclosed in a sac contiguous to the cloaca (XXXVII. 4; XXXVIII. 7, 8). Ehrenberg remarked these granular heaps in *Microcodon*, *Lacinularia*, *Stephanoceros*, *Floscularia ornata*, *Enteroplea*, and in *Notommata granularis*, and called them at one time "a dark glandular body or speck," at another "a single glandular organ" having no evident function. Weisse represented them to be unconsumed and still-remaining yolk-substance, and supposed the animals presenting such granular masses "premature" or "aborted." Williamson noticed similar masses in *Melicerta*, and found that they disappeared soon after the young animal escaped from the ovum.

Leydig's conclusion, from optical and chemical qualities of the granules, is that they are urinary or uric concretions, and that the clear space containing them is formed by the end of the intestinal canal, or by the cloaca. To elucidate this view, an analogy is pointed out in the case of those insects which undergo complete metamorphosis, in which solid urinary concretions accumulate in the rectum during the pupa-state, but are evacuated when the insect emerges from that torpid condition.

The actual secreting organ of these urinary concretions, or in other words the kidney, must, says Leydig, be sought for in the cells of the intestinal wall, which stand out in a knob-like matter. Ehrenberg's account of the "dark bodies" about the rectum of *Enteroplea*, and of *Notommata granularis*, favours this opinion; and the granular heap near the termination of the intestine of the larva of *Cyclops* may be adduced as another allied fact in illustration of the nature of the bodies in question. Vogt, however, is opposed to this presumed analogy, and states that this peculiar collection in the cloaca of embryo *Cyclopes* is originally produced of a green colour, within a sac on each side of the intestine, and when subsequently discharged into the cloaca, is of a yellow hue. These sacs therefore have, in his estimation, rather the signification of a liver than a kidney. The like structures are common enough in Vermes. Excepting therefore, Leydig contends, male Rotifers, urinary concretions occur only in the embryo and in the first period after birth, and the existence of a primordial kidney must be admitted as a fact. Cohn has come forward to oppose these views of Leydig, and says that this whole hypothesis falls with the proof that in *Enteroplea* the vesicle with the dark granules stands in no sort of connexion with the intestine, nor, indeed, can do so, as no intestine exists, and it is rather firmly adherent to the outer wall of the testis. To this adverse opinion Leydig rejoins (Müller's *Archiv*, 1857, p. 404, and *A. N. H.* 1857, xx. p. 295) that Cohn's "undoubted proof" is itself an error; "for the clear space containing the dark granules is not adherent to the true wall of the testis, but to that outer envelope which represents the rudimentary stomach and intestine; or, more properly speaking, the clear space enclosing the concretion belongs to the abortive alimentary canal itself, which extends from the notch of the rotary organ to the cloacal opening, so that *Enteroplea* displays the same characters as the other Rotatoria, although this is in complete opposition to the description given by Cohn. My opinion, that the granules in question are uric concretions, is, of course, no more strongly supported by the position of matters detected in *Enteroplea* than before; but the objection raised by Cohn appears to be removed. The opinion first put forward by Weisse, which is also favoured by Cohn, that the granules are the remains of unused yelk-masses, I must reject, without taking other reasons into account, if only because the vitelline elements and the granules in question have no resemblance to each other, but are perfectly different things."

Several authors have suggested that the vascular apparatus to be described as a respiratory organ in the following chapter has also in part, or even principally, the function of a kidney or excretory organ. These views can be best propounded after the apparatus in question has been described.

THE VASCULAR AND RESPIRATORY SYSTEMS (XXXVIII. 26 *e*, *i*, *l*; XL. 1 *i*, 5).—The existence of vessels subservient to the circulation of a fluid analogous to blood was surmised by Ehrenberg. Among such assumed structures were the transverse cords to which the semblance of articulation is often due, as well as other similar bands now proved to be muscular fibres of connective tissue. For instance, the intercurrent fibres about the head and neck of the Rotatoria, and the interlacing cords passing forward to the lobes of the rotary organ, and backward to the maxillary head, were reckoned parts of the vascular system.

The purpose of a circulatory system is to convey the blood (the nutritive, reparative fluid) within the reach of every tissue and organ, so that all its parts may be renovated, and their effete, worn-out particles removed. The necessity for such a contrivance is at once intelligible in large animals, where the parts have considerable size and thickness, and are pretty closely packed within the limits of the body; but in the case of the Rotifers, the protoplasmic fluid fills up all the large space within the body unoccupied by the viscera, and is in immediate contact with them, whilst none of them have such a density or thickness as to preclude their being readily permeated by it. The result of digestion within the alimentary canal is the production of a nutritive juice or chyle, which apparently passes by exosmosis through the walls of the canal into the general cavity of the body, mixing there with that already existing, and is the representative of the blood of higher animals. But, in addition to this, a constant renovation of the chyliferous liquid of the body, by water taken in from without, appears to be necessary.

Ehrenberg witnessed a periodical transparency in the body, with an alternating distension and collapse occurring regularly in almost all Rotatoria. During distension, the outline of all the viscera seemed clearer, whilst, upon the collapse, the organs approximated their limits, became less defined and somewhat confused, and the integument crumpled. These movements he attributed to the alternate entrance and exit of water from without, through the medium of the supposed siphon tube on the head, or of openings upon other parts of the body. It has, however, been shown that the siphon and apparent openings have no external communication; we must consequently believe, with Leydig, that the imbibition and exudation must be, in great measure, the result of endosmotic action,—not forgetting, however, the influence which is necessarily exerted on the alternate movements in question by the action of the respiratory apparatus to be presently described.

Leydig remarks that "the mingling of the sanguineous fluid with water from without seems, at first sight, extraordinary; it is, however, a fact in physiology, founded on direct observation, Van Beneden having detected it in marine *Mollusca*, myself in *Paludina vivipara*, and, more recently, Gegenbaur in *Heteropoda* and *Pteropoda*." The nutritive or sanguineous fluid of the Rotatoria is, as a rule, clear and colourless, but in some species it has a red or yellowish hue, *e. g.* in *Notommata centrura*, *Synchæta*, and *Polyarthra*; it is, moreover, usually destitute of distinct floating particles or elements: exceptions occur in *Eosphora Najas*, *Euchlanis*, and a few others, in which small clear corpuscles move about in it just as in the blood of Annelida. "Such genuine elements," continues Leydig, "of the circulating fluid must, however, not be confounded with the minute particles which at times detach themselves from the tissues within the body and float about in the liquid. Such false corpuscles are not uncommon in animals which have been partially crushed or left dry by evaporation; those noticed by Ehrenberg in *Hydatina senta* were, in all probability, of this accidental kind."

Dr. Dobie has recorded an observation of seemingly genuine moving corpuscles, which deserves a place here. He found, "immediately below the integument of *Floscularia cornuta*, groups and lines of very small granules continually in a state of rapid molecular motion, in appearance exactly resembling the molecules in the cusps of *Closterium*. Besides the molecular, they are subject to another motion; for occasionally they move from one part of the surface to another, in currents not very distinct or persistent, and in no definite direction. He has seen them running in lines down the tail, and collecting in groups. This flowing movement occurs chiefly during the contractions and relaxations of the entire animal. He thinks it probable that these granules are connected with the nutrition of the animal, and analogous to the free floating corpuscles of the *Tardigrada*, described by M. Doyère."

In his recent paper (Müller's *Archiv*, 1857, p. 404), Leydig notes that when individuals of *Hydatina senta* have been plentifully fed with *Euglena viridis*, the fluid (blood) which fills their abdominal cavity, contains numerous clear globules, or blood-corpuscles, of a roundish form and unequal size. We would rather compare these corpuscles to those seen in chyle during the process of digestion, as more strictly homologous with them than with blood-disks. Although no true vascular system is discoverable in the Rotatoria, there is, nevertheless, a tubular apparatus readily seen in most animals of the class (XXXVI. 6 *a a*, 9 *m*; XXXVII. 29 *d*, 32 *e f*; XXXVIII. 5 *d d*, 25 *e f*, 26 *e i l*, 27 *g*). It has the form of an apparent band, extends upwards from the cloaca, or near to it, on each side of the body; and within this a cord or vessel is visible, more or less coiled or convoluted in its course, from which small vibrating organs, often pear-shaped, and likened by Ehrenberg to written notes of music, project towards the cavity of the body. These vessels may possibly communicate by one or more transverse vessels running across the neck of the animal; whilst below, they end either in a vesicle endowed with an active power of contractility or immediately in the cloaca itself.

Now it happens that the mechanism of this organization, as well as its functions and relations to the other parts of the body, have been so variously described by different writers, that it is difficult to draw up any satisfactory general account of it; we shall therefore be compelled chiefly to confine ourselves to the reproduction of the several statements as presented by their authors respecting the side bands and the contractile vesicle. Ehrenberg adopted the curious notion that they were parts of the sexual organization. The side bands with their coiled canal he represented to be the testes, and the contractile vesicle a sperm-sac (seminal vesicle). The inconsistency of this notion with all our knowledge of animal structure and functions, has struck every observer. To adduce but one counterargument:—the constant discharge of spermatic fluid in a profuse quantity, and in no relation with the number of eggs contained within the ovary, is an idea which is *per se* at variance with all analogy, and directly opposed by the fact that the apparatus is in full activity even when the embryo is still unhatched within the body of its parent,—and entirely negatived, at least in several instances, by the discovery of distinct male beings.

Again, Ehrenberg called the tremulous tags (XXXVIII. 26 *e*) gills or gill-like organs, and therein recognizes them as parts of a respiratory system. He thus refers to them:—"Oval, tremulous bodies are in some species observed attached to a free filament-like tube generally placed longitudinally within the body; in some instances they are attached to the two sexual glands (*i. e.* the side bands), as in *Hydatina*. Their function is respiratory, and they are analogous to gills; the tremulous motion observable is that of the laminæ composing them. The reception of water within the body for these gills to act upon, is provided for by one or more openings at the anterior part of the body, or in some species by spur-like processes or tubes (siphons)."

The erroneous belief that the siphon-like antennæ (XXXVII. 17 *d*; XXXVIII. 27 *e*) and the cuticular fossæ were channels for the admission of water into the body was countenanced by Siebold, who explained the respiratory act to consist in the entrance of water, by the supposed apertures, from without into the general cavity of the body, its percolation through "short lateral vessels" (the oscillatory tags) into the winding canal of the lateral band of each side, and its passage thence into the contractile vesicle, by which it is pumped out through the cloaca. This process Siebold designated a water-circulating system.

Mr. Dalrymple, in his excellent description of a supposed new *Notommata* (the *Asplanchna Brightwellii* of Gosse), differs from Siebold in the account of the respiratory apparatus in several particulars. He says—"This peculiar organ consists in a double series of transparent filaments (for there is no proof of their being tubes or vessels), arranged, from above downwards, in curved or semicircular form, symmetrical when viewed in front (XXXVI. 6 *a a*). These filaments, above and below, are interlaced, loop-like, while another fine filament passes in a straight line like the chord of an arc, uniting the two looped extremities. To this delicate filament are attached little tags or appendices, whose free extremities are directed towards the interior of the animal, and are effected by a tremulous, apparently spiral motion, like the threads of a screw. This is undoubtedly due to cilia arranged round these minute appendices. The tags are from eight to twelve, or even twenty, in number, varying in different specimens (XXXVI. 6).

"I believe the organ in question to be a peculiar circulatory system. The body of the animal is filled with fluid, most probably analogous to blood, while the ciliated tags, in perpetual motion, must produce currents in this fluid, and probably in a uniform and determinate direction. In this way the nutrient plasma will be brought regularly in contact with all parts of the body, and the process of nutrition go on as in insects, without the intervention of tubular vessels,—the dorsal heart in them serving only to give direction and circulation to the blood. I am the more impressed with this belief, since these filamentous organs are in close approximation with the large contractile sac, which probably performs a respiratory function."

Moreover Mr. Dalrymple does not believe in any communication between the sac and the apparatus furnished with the ciliated tags, as Siebold supposes; on the contrary, he represents the sac to communicate directly with the exterior. He writes—"This sac, spherical when distended, is placed just above the ovisac, and communicates with the vaginal canal. It is exceedingly delicate, and may be seen to contract, by the action of muscular fibres, with great rapidity, in which act it is thrown into numerous regular folds or pouches, and in that condition appears not very dissimilar to the large cellular lungs of Batrachia.... The explanation which I venture to give is, that this sac draws in water and expels it again by the vaginal orifice; and it is by bringing the blood, by means of the ciliary movements of the tags, into immediate contact (the delicate membranous wall of the sac intervening) with the air of the water, that aëration or respiration is performed. An analogous contractile sac may be seen in *Rotifer vulgaris*."

Lastly, the author adds that he is convinced, from repeated observation, that the contractile sac has no relation with the generative function, and that "the supposed vascular ramifications upon it are neither more nor less than the muscular fibrillæ by which the contractions are effected."

Perty coincides with the explanation offered by Dalrymple, and reproduces it in his work. Mr. Gosse presents, in his notice of *Asplanchna priodonta*, the following description of the mechanism in question:—"On the upper side of the oviduct sits a contractile bladder, which, when full, is perfectly globular and small, being scarcely, if at all, larger than the two pancreatic glands put together. Round this, attached at or near its base, passes on each side a tortuous thread, apparently glandular, which goes up along each side of the ventral region, and is attached to the head-mass behind the jaw-cushion. The middle part of each thread is wrinkled into a large plexus of four or five pairs of doublings, laid with some regularity; on this plexus are placed four tremulous tags, directed inwards, making eight in all. None are visible on any other part of the threads. The presence of these organs, as well as of the contractile bladder, in the female, shows that these are not connected with impregnation.

From the above extract it appears that Mr. Gosse believes that the "tortuous threads" of the apparatus have a glandular office; and though he so far countenances the hypothesis of Ehrenberg, nevertheless pronounces against their sexual nature.

Dujardin expresses an opinion that the contractile vesicle is a respiratory organ, and that the water freely penetrates into the interior of the body to bathe the vibratile organs, as the variability of volume of the animals proves.

Leydig has very elaborately described the structures in question, and their several modifications. We feel justified in submitting an analysis of his researches, even at the risk of some repetition:—

"The canal of the respiratory apparatus extends along each side of the body. Generally there is a single canal on each side, much contorted in its course, and forming actual coils or plexuses, *e. g.* in *Stephanoceros*, *Brachionæa*, *Lacinularia*, *Euchlanidota*, and many *Notommatæ*. Two canals, which coalesce at either end, are seen in *Notommata Myrmeleo*, *N. Sieboldii*, *N. Syrinx*, *N. clavulata*, and *N. Anglica*. The canals have a thick cellular wall, and their cavity is clear and well defined. They are not solid cords, as Perty and others affirm. The cellular walls may be much thickened, and contain, besides the usual fine granular contents, many fat-particles, as seen in *Stephanoceros*, *Notommata centrura*, and in *Lacinularia*. In the first-named, indeed, the deposit of fat is so great that the coils of the respiratory canal near the head rather resemble a collection of fat-vesicles (XXXVII. 1 *t*). I have not been able to discover any anastomoses between the canals of opposite sides, as Huxley represents in *Lacinularia*."

In many Rotatoria, particularly in small species, such details of structure escape our powers of observation, and the canals described are invisible, as, for example, in *Floscularia*, *Polyarthra*, and *Ascomorpha*; a more close and searching inquiry may, however, reveal them, particularly where the contractile sac shows itself. Indeed, Perty has detected the tubes in *Ascomorpha Helvetica*.

"The vibratile or ciliated tags are processes of the respiratory canal (XL. 5). They are constructed after two types, which do not concur in the same animal, but are found as peculiarities of different genera. In one type the process is of equal width and cylindrical throughout, as in *Notommata Myrmeleo* (XXXVII. 29 *e*, 32 *k*); in the other, the extremities are dilated and a trumpet-shaped figure assumed, as in *Notommata centrura* (XXXVIII. 26 *e*), *Euchlanis triquetra*, and in *Eosphora Najas*.

"In *Lacinularia* I have been unable to satisfy myself if these processes of the respiratory canal discharge themselves freely into the abdominal cavity. Huxley states that they have blind extremities; but I regard it as still an open question, for in other species, for example in *Notommata Sieboldii* and *N. centrura*, it can be most satisfactorily made out that they open freely into the cavity of the body.

"Vibratile hairs (cilia) project from their free end and in the trumpet-shaped processes; the direction of the ciliary motion is evidently inward.

"The number of the vibratile organs varies much in different species: usually there are but from 4 to 8 or 10, distributed at unequal distances along the respiratory tube; but in some animals, *e. g.* in *Notommata Copeus*, *N.*

Syrinx, N. Sieboldii, N. Anglica, N. clavulata, and in *N. Myrmeleo,* the number is greatly augmented, and from 30 to 50 tags may be counted. When thus multiplied, they are for the most part appended to a clear canal of little width and thickness, rather than to one with thick cellular walls. (The tags are mostly more numerous on one side than on the other.)

"The posterior extremities of the respiratory canals either open at once into the cloaca, as in *Tubicolaria,* or more commonly expand to form the contractile sac, the respiratory vesicle (XXXVIII. 26 *i*).

"At the first appearance of the respiratory vesicle, it is of insignificant size, and clearly a dilated state of the united ends of the two respiratory canals. It is then little or not at all contractile. This condition is illustrated in *Lacinularia* and *Stephanoceros.* "It generally, however, exists as a considerable and actively contractile sac opening into the cloaca. Its walls are very thin, and covered with a fine muscular network, discoverable in most species, and imagined by Ehrenberg to be vascular. The openings of the respiratory canals into this sac are readily perceived by a proper adjustment of the focus of the microscope."

From this organization, Leydig concludes that a portion of the water surrounding the animal enters by *endosmosis,* or possibly by minute orifices hitherto unperceived, within the cavity of the body, and there mixes with the nutritive juices, the analogue of the blood of higher beings. The simple act of respiration is consequently limited to the imbibition and the intermixture of fresh water with the blood. Further, it would appear that the waste material is discharged through the vibratile processes, which by their ciliated appendages direct the fluid into the respiratory canals, from which it escapes either first into the contractile sac, and thence into the cloaca, or at once into the latter.

Here the question of a glandular, a renal function performed by the respiratory tubes meets us; but it will be more convenient to defer its consideration until we have set forth the researches of Mr. Huxley, who differs in not a few details from Leydig:—we must premise that they apply specially to the *Lacinularia socialis,* to which, among other peculiarities, he assigns the absence of a contractile sac, although Leydig affirms a very small one to exist.

Prof. Huxley acquaints us that the opinion of Oscar Schmidt is, "that the ends of the water-vessels are closed, and that the vibrating body is within them." And he goes on to say—"There is no contractile sac opening into the cloaca as in other genera; but two very delicate vessels about $\frac{1}{400}$th of an inch in diameter, clear and colourless, arise by a common origin upon the dorsal side of the intestine. Whether they open into this, or have a distinct external duct, I cannot say.

"The vessels separate; and one runs up on each side of the body towards its oral side. Arrived at the level of the pharyngeal bulb, each vessel divides into three branches: one passes over the pharynx and in front of the pharyngeal bulb, and unites with its fellow of the opposite side, while the other two pass, one inwards and the other outwards, in the space between the two layers of the trochal disk, and there terminate as cæca. Besides these, there sometimes seemed to be another branch just below the pancreatic sacs.

"A vibratile body was contained in each of the cæcal branches; and there was one on each side in the transverse connecting branch. Two or more were contained in each lateral main trunk, one opposite the pancreatic sacs, and one lower down, making in all five on each side. Each of these bodies was a long cilium ($\frac{1}{1400}$th of an inch) attached by one extremity to the side of the vessel, and by the other vibrating with a quick undulatory motion in its cavity. As Siebold remarks, it gives rise to an appearance singularly like that of a flickering flame.

"I particularly endeavoured to find any appearance of an opening near the vibratile cilium, but never succeeded, and several times I thought I could distinctly observe that no such aperture existed. Animals that have been kept for some days in a limited amount of water are especially fit for these researches. They seem to become in a manner dropsical; and the water-vessels partake in the general dilatation.

"The band which accompanies the vessel appeared to me to consist merely of contractile substance (connecting-tissue), and to serve as a mechanical support to the vessel. It terminates above in a mass of similar substance containing vacuola attached to the upper plate of the trochal disk."

This account differs from that of Leydig chiefly in the denial of the patent condition of the free ends of the vibratile tags, and consequently of the entrance of the fluid from the cavity of the body through them into the lateral vessel. It also casts doubt upon coils of the water-vessel in the neck, and upon the presence of a small non-contractile sac at the inferior termination of the lateral vessels, whilst, on the other hand, it represents anastomosing branches between the vessels of opposite sides in the neck. Mr. Huxley's description therefore appears rather to favour Mr. Dalrymple's hypothesis as to the contractile vesicle, whilst, with respect to the lateral canals, it is suggestive of a glandular excretory function.

Dr. Carpenter adopts Prof. Huxley's description of the tags, and of the inosculating vessels in the neck.

Cohn, in his account of *Hydatina senta* (*Zeitschr. f. Zool.* 1855, p. 444), describes two tubes as springing from the thick-walled, muscular contractile sac, lying on the abdominal surface of the animal, immediately subjacent to the skin, and communicating with the cloaca. These tubes are "respiratory canals;" they have a finely granular wall, and advance with more or fewer curvatures and coils towards the head, where they appear to end in straight, blind, pointed ends or in loops, which attach themselves to the skin of the rotary organ. The "tags," four on either side, affixed to the canal are triangular in one aspect, and shortly cylindrical in another, and supported on short pedicles, through which their cavity becomes continuous with the interior of the canals. The different figure of the tags from different points of view has given rise to the error of their being of two sorts—cylindrical and triangular. In *Brachionus militaris* the contractile vesicle is remarkable on account of its very large dimensions. It occupies as much as two-thirds of the abdominal cavity, and is composed of two chambers, of which the posterior is the larger. The diastole and systole of the two chambers are alternate; the posterior opens into the cloaca, through a small duct. That there is a direct communication between the contractile sac and the cloaca, Cohn decisively proved by mingling colouring matter in the water, and witnessing a current inwards during each dilatation, and one outwards on each act of contraction, alternately—an experiment sufficiently conclusive of the respiratory nature of the sac.

The mechanism under consideration appears, as Leydig also remarks, to be occasionally absent—or perhaps only imperceptible. Dr. Dobie states that in *Floscularia* "no trace of a vascular system can be observed. The tremulous gill-like organs found in some Rotifers are here absent." After his complete examination of *Melicerta ringens*, Prof. Williamson says—"I have found no special organs of circulation or respiration. . . . I detect no vessels or pulsating organs." Nevertheless a structure at least resembling the vibratile tags was noticed in this animal by Mr. Gosse, who states that between the gizzard "and the base of the stomach there was one little tremulous tag, of the same structure as in *Notommata aurita*. From the same spot also project, into a space of peculiar clearness, two trumpet-shaped bodies of the greatest delicacy, and without motion." Prof. Williamson reminds us, in a note, that he has described two tubes springing from a pyriform organ, apparently hollow, and located immediately below the stomach. Though he saw no pulsation in this organ, it appeared to be the homologue of the contractile vesicle in other species. He believes the two filamentous organs to be tubular, and suggests the possibility of their supplying a spermatic secretion, though he is not able to affirm it as a fact. He moreover observed the vibratile spermatozoon-like corpuscles "in various parts of the body, where they are apparently enclosed within hollow canals. I have never seen them occupying the two main trunks of the *water-vascular system*, as cæca, nor can I succeed in tracing any connexion between them;" but it is probable that they were really located in some of the branches of that system, as observed by Mr. Huxley in *Lacinularia*.

The glandular renal function of the lateral tubes and appendages has the support of analogy among other lowly-organized forms allied to the Rotatoria; but such an hypothesis falls to the ground, if, as Leydig thinks, the urinary concretions noticed and so named by him in embryo and young animals are deposited within the cavity of the intestine, and not in the contractile sac. However, naturalists generally will certainly not accept the doubtful discovery of the position and the interpretation of the nature of the particles offered by Leydig as conclusive evidence of the nature of those structures, but will, in the absence of direct and exact observation, be rather guided by analogy. We will therefore append some extracts, showing the comparative physiology of the supposed respiratory mechanism.

Leydig writes—"There is the greatest similarity between it and the organs in *Lumbricinæ* and *Hirudinæ*, which are conceived to have a respiratory office. In these are similar contorted and coiled tubes, with a clear canal opening either without an intermediate contractile sac, as in *Clepsine*, or with one, as in *Nephelis*. Moreover, the canal opens by a wide ciliated aperture into the cavity of the body; and in this termination of the tubes I recognize the homologue of the vibratile tags of the Rotatoria. Moreover, the direction of the ciliary motion in the Annelida is inwards to the main canal. In the *Lumbricinæ*, Gegenbauer has attributed a renal function to the otherwise-called respiratory canal."

Dr. Carpenter describes a "water-vascular system" among all the vermiform members of the Articulata, and as represented in its simplest type in the Rotifers. "Similar lateral vessels, often ramifying more minutely (especially in the head and anterior part of the body), are found in many of that group of vermiform animals clothed over the whole surface of their bodies with cilia, to which the designation Turbellaria has been given." This writer surmises that the water-vascular system may contain some other fluid than pure water, and, as Van Beneden has suggested, may serve as a urinary apparatus.

Prof. Huxley presented the following philosophical summary of the comparative relations of the respiratory mechanism of the *Rotifer*; before the British Association:—"In certain Distomata, such as *Aspidogaster*, there is a system of vessels of essentially similar character with that in *Rotifer*; but the principal canals, those lateral trunks which come directly from the contractile vesicle, present regular rhythmical contractions. The smaller branches are all richly ciliated. In other Distomata the lateral trunks appear to be converted into excretory organs, as they are full of minute granules: they remain eminently contractile; but their connexion with the system of smaller ramified vessels ceases to be easy of demonstration. They still form one system; but the cilia are no longer to be found in the smaller ramified vessels. In certain *Nematoidea* the vascular system is reduced to a couple of lateral contractile vessels altogether devoid of cilia, but communicating with the exterior by a small aperture. Now in all these cases there is no doubt the vascular system is, physiologically, a respiratory and perhaps a urinary system, while the common cavity of the body represents the blood-vascular system of the Mollusca and Articulata. If this system, then, be not at all homologous with the blood-vascular system of the higher Annulosa, it is so with the tracheæ of Insecta."

We may repeat here that the delicate and ciliated rotary organ must in some measure subserve the purpose of respiration, after the manner of the gills of a reptile or of a fish, by providing for the aëration of the liquids contained within it through the agency of the constantly renewed contact of fresh water flowing over its actively-vibratile surface.

OF THE NERVOUS SYSTEM AND THE ORGANS OF SENSE; PSYCHICAL ENDOWMENTS.

a. *Of the Nervous System.*—The existence of a rudimentary nervous system is now universally admitted; but at the period when Dujardin wrote, that talented observer felt that the state of knowledge respecting the Rotatoria was not sufficiently precise to establish the existence of nerves and of nervous ganglions. His scepticism was, no doubt, increased by observing the unphilosophical facility with which Ehrenberg described and represented nerve-cords and ganglions according to preconceived notions and loose analogies. Illustrations of Ehrenberg's supposed nervous apparatus, and of its modifications of form in different animals, are to be found in his descriptions of every family and genus. Thus in giving the characters of *Lacinularia*, he says that "near the œsophagus is situated a nervous mass, the analogue of a brain divided into four or six lobes; also, as in *Megalotrocha* (XXXII. 374), two ring-like and radiating masses with a row of ganglions lying beneath the muscles of the ciliary wreath." In *Melicerta*, he speaks of a curved gland-like band of nerve-matter; in *Enteroplea*, which has no eyes, of a brain-like knot, sending off a thick tortuous nerve-cord along the dorsal surface to the second transverse vessel, where the respiratory opening probably exists; of a ganglion placed beneath the eye in twenty-six species of *Notommata*, which in *N. Copeus* and *N. centrura* is three-lobed and seated above the maxillary bulb, whilst in the remainder it consists of one or more nervous ganglia seated amidst the muscles of the ciliary apparatus; and in *Otoglena*, of an oval cerebral ganglion with two dark appendages, a red eye, a long nerve-loop in the neck, with a prolongation backward, a forked ventral nerve, and two ear-shaped frontal protuberances bearing two visual points.

It would be useless to multiply these references; the general deduction from the many descriptions of Ehrenberg is, that there exists a cerebral or brain ganglion, which supports the eyes, and by its extension encircles the œsophagus like a loop, sending off nerve-cords in every direction, and often complicated by the presence of other nerve-ganglions about the head, neck, and body. Moreover, the apparent reticulations frequently visible below the ciliary wreath, which he sometimes viewed as a vascular network, he at others spoke of as a nervous plexus.

The present prevailing opinion is similar to the above, viz. that there exists a brain or central nerve-ganglion above the œsophagus, with outgoing nerve-fibres, and sometimes accompanied by supplementary ganglia in other regions. Nevertheless the special descriptions of Ehrenberg are not accepted; the portions of tissue fixed on by him as nervous masses, receive in general an entirely different interpretation. Thus in the case of *Lacinularia* the supposed 4–6-lobed brain, with extending nerve-fibres, is set down as mere collections of "vacuolar thickenings," with intercurrent fibres of connective tissue. The same interpretation is extended to the "nine pairs of ganglia, with fine interlacing nerve fibres," in *Notommata clavulata*, and to the four or five such in *Diglena lacustris*; yet in both these species, the central or brain ganglion represented by Ehrenberg is allowed to retain this character by Leydig, who sets aside all the rest as mythical.

The following critique on Ehrenberg's views is from Prof. Williamson:—"The small organs so common amongst the Rotifera, and which Ehrenberg regards as nervous ganglia, are abundant in the *Melicerta*, but they afford no countenance to the hypothesis of the great Prussian Professor (XXXVII. 17 *k*). They appear to be nothing more than small cells, or vesicles, formed of granular viscid protoplasm, very similar to those into which the yelk of the egg becomes divided. Sometimes they float freely in the fluid which distends the integument and bathes the viscera; at others, thin ductile threads pass from one vesicle to another.... There is no uniformity in their arrangement in different individuals. They differ as widely as possible in their size, number, and distribution. So far from being nervous vesicles, they appear rather to be cells modified into a rudimentary form of areolar (connective) tissue. That they are hollow vesicles or cells, very viscous, readily cohering, and, owing to this coherence, readily drawn out by the movements of the various organs to which they are attached, are facts capable of easy demonstration."

A central nervous mass or brain, immediately subjacent to the eye-specks, and above the œsophagus or pharynx, which sends off nerve-fibres in different directions, is, as already intimated, generally admitted to exist. It is mentioned by Siebold, Perty, Gosse, Dalrymple, Leydig, Cohn, and others. The two first-named authors allude to it as a group of ganglions; but Leydig affirms that, although it may be lobed, it is always a single and undivided organ. Some, again, have treated of it as forming a loop or ring around the gullet; but such a condition is denied by Leydig, who states that it only extends itself in the form of diverging nerves, which end by enlarged extremities, and never form loops, such as Ehrenberg represented, around the tubular process or respiratory siphon.

This nervous centre or brain, supporting the eyes, is seen in the families *Hydatinæa*, *Euchlanidota*, and *Brachionæa*. Leydig, however, cannot admit the masses supposed to represent the cerebrum in the families *Œcistina*, *Megalotrochæa*, and *Floscularia*, nor the pairs of nerve-like ganglions at the base of the trochal disk of *Stephanoceros*, to have a cerebral character; he supposes them rather to be "coils of the respiratory canal, or heaps of granules or nuclei, such as are met with beneath the cuticle."

Prof. Huxley discovers the nervous centre under a peculiar and unusual usual form in *Lacinularia socialis*. To quote his words—"On the oral side of the neck of the animal, or rather, upon the under surface of the trochal disk, just where it joins the neck, and therefore behind and below the mouth, there is a small hemispherical cavity (about $\frac{1}{1400}$th of an inch in diameter), which seems to have a thickened wall, and is richly ciliated within. Below this sac, but in contact with it by its upper edge, is a bilobed homogeneous mass (about $\frac{1}{800}$th of an inch in diameter), resembling in appearance the ganglion of *Brachionus*, and running into two prolongations below; but whether these were continued into cords, or not, I could not make out.

"I believe that this is, in fact, the true nervous centre, and that the sac in connexion with it is analogous to the ciliated pits on the sides of the head of *Nemertidæ*, to the 'ciliated sac' of the Ascidians, which is similarly connected with their nervous centre, and to the ciliated sac which forms the olfactory organ of *Amphioxus*.

"Mr. Gosse has described a similar organ in *Melicerta ringens*; and I have had an opportunity of verifying his observations, with the exception of one point. According to this observer, the cilia are continuous from the trochal disk into the cup; so far as I have observed, however—and I paid particular attention to the point,—the cilia of the cup are wholly distinct from those of the disk. The interesting observations of the same careful observer, upon the architectural habits of *Melicerta*, would seem to throw a doubt upon the propriety of ascribing to the organ in question any sensorial function. But however remarkable it may seem that an animal should build its house with its nose, we must remember that a similar combination of functions is obvious enough in the elephant."

This last analogy is assuredly very far-fetched, and can serve nothing in the argument; and to us it seems a much more reasonable supposition that the homogeneous bilobed body below the ciliated cup is a gland, than that it is a brain; were it a brain, surely some nerve-fibres would be traceable from it into the interior of the animal. Of this body Prof. Williamson says—"I see no sufficient reason for assigning to the small organ nervous functions;" and he further remarks that "the ciliated sac or cup becomes so contracted when the animal is not busy in constructing its case, as to be almost invisible," which is another circumstance discountenancing Prof. Huxley's notion of its purpose. Cohn has no doubt of the cerebral nature of the large semiglobular mass, noticed also by Ehrenberg, in the head of *Hydatina senta*; and he records having frequently observed in its interior a large, transparent, circular vesicle or vacuole. A large number of nerves are given off from its anterior portion; but from its posterior, two thick fibres proceed backwards and outwards to the apparent ciliated opening on the surface of the back, and constitute a cervical loop. There is, however, no actual opening, but merely a ciliated fossa, which is probably a sentient organ. About the large cerebral ganglion are other lobules, also probably nervous, from which fibres are given off and possibly form a plexus between the alimentary tube and ovary, besides supplying the muscles. Above the ciliated fossa named, is another depression supplied with nerves; and, according to Ehrenberg, a similar one is present on the opposite side of the body.

Various accessory ganglions or nerve-centres have been represented by authors at different parts of the body, mostly in relation with some of the principal organs, this arrangement being suggested by the known nervous system of other Invertebrata—for instance, the Mollusca, which have usually a special ganglion for the nervous supply of each principal organ of the body. Such a multiplication and disposition of ganglia, Oscar Schmidt endeavoured to demonstrate in *Brachionus urceolaris* and in *Hydatina senta*. His interpretation has, however, not been accepted by others, and, generally, the characteristics of ganglions are so ill-defined, that the bodies considered to be such by the observer are pronounced to be no other than vacuolar thickenings of connective or other dissimilar tissue by others.

Perty makes the statement that in *Hydatina*, *Synchæta*, and *Diglena* there is a series of ganglions along the anterior surface of the abdomen, with connecting nerve-fibres between them and the brain. A nervous system of this sort belongs to the higher Crustacea; but although many have sought it in the Rotatoria, Perty is the only observer who has affirmed its existence in any.

Mr. Dalrymple mentions the presence, in his *Notommata anglica*, of a small ganglion sending off nerves to the stomach, salivary glands, and ovary; but Leydig looks upon this structure as no more than the cells and fibres of connective tissue, and states that "similar clear cells, of various size, having delicate elongated branches, are seen in *Notommata centrura*, *N. Myrmeleo*, *N. clavulata*, and in *Diglena lacustris*. The delicate branches, or threads, extend between the epidermis and the viscera of the body, and were described by Ehrenberg to be nerves, but are actually the means of retaining the viscera *in situ*,"—a conclusion supporting that of Prof. Williamson.

There is, however, one set of nerves recognized by most observers, which proceed from the cerebral ganglion to the surface of the body, ending at the bottom of the epidermic pits described above (p. 403), from which stiff cilia or bristles project, or, otherwise, running to the extremity of the protuberances and antenna-like processes, which are also armed with bristles. Dalrymple noticed nerves so distributed in *Notommata anglica*; and Leydig has indicated the like in many species. The supply of a nerve to the so-called siphon or respiratory tube imparts to it the character of an antenna, tactile organ, or feeler. The evident delicate band or cord seen within the tubular process of *Melicerta* is indeed called by Mr. Williamson a muscular band; yet at least some portion of it must be esteemed a nerve-cord, if the organ in question really possesses tactile powers.

A similar distribution of nerves is witnessed in the Turbellaria, and, as Leydig says, among the Phyllopoda and Arthropoda.

Nervous substance has its origin in simple cells, which in ganglia retain their cellular character, but in nerves appear to be elongated as tubes,—the cell-wall constituting the nerve-sheath or the neurilemma—the cell-contents (the contained nerve-tissue) existing as a fine molecular matter. In nerve-masses or ganglions the original nuclei remain, and the several constituent cells are aggregated and held together by diffused connective tissue. Some peculiar structures, supposed to stand in especial relation to the nervous system, are described by Leydig. We cannot do better than follow his account in an abstract.

Immediately above or about the brain-ganglion, in many genera, a sac is observable filled with a whitish substance, called by Ehrenberg the "chalk-sac" (Kalkbeutel). Leydig confesses that he has hitherto been unable to determine whether this sac is in immediate connexion with the brain, or independent of it. In *Notommata centrura* (XXXVIII. 26 *t*) it appears as a process or lobe of the brain; but in another species, *N. aurita*, the sac is so elongated as to form a thin stem filled with the chalk-like matter, which it seems to discharge by an opening on the head. This organ would therefore seem to partake of the nature of a gland. Beside the genera named, this sac is seen in *Notommata tripus*, in *N. collaris*, and in *N. tardigrada*; also, if the black speck noticed by Perty be the same structure, in *N. roseola*. Ehrenberg refers to its existence in *Diglena*, *Megalotrocha*, and *Brachionus*; but in the last-named genus Leydig has failed to discover it.

The vesicular space or sac is, in several instances, not single; but two, three, or four are noticeable. Thus in *Megalotrocha* Ehrenberg mentions four opaque, white, spherical bodies at the base of the rotary organ.

Another sac, distinct from the foregoing, is seen in *Euchlanis* and *Notommata centrura*, lying in the median line close above the brain, and discharging itself by a duct passing forwards to the cuticle. It contains no chalky matter, but is translucent and composed of clear cells. The peculiar and considerable organ which Leydig met with in *Stephanoceros*, placed in advance of the stomach, and consisting of a group of hyaline vesicles with a discharging orifice on the neck, its observer is inclined to refer to the same category with the problematical structures of *Euchlanis* and *Notommata centrura*. He moreover seeks to establish an affinity between these organs and the small clear space surmounted by a ring on the cuticle, situated in the middle line of the body, behind the frontal speck in Phyllopoda, such as *Branchipus*; but even if this affinity be admitted, no light is thrown upon the functions of these questionable structures.

b. *Organs of Sense.*—The existence of some of the senses is to be inferred from that of a nervous system. The sense of touch is one concerning which there can be no question; that of taste, in its nature allied to the tactile sensibility, is very doubtful, whilst those of smelling and hearing may be pretty safely stated to be entirely absent. Lastly, the sense of sight is generally admitted to exist, and to have special organs, or eyes, for its exercise.

Touch may be supposed to be diffused as common sensibility over the entire surface of the body, and especially developed in the soft tissue of the rotary organ, in its processes and antennæ, and in the soft processes and termination of the pseudopodium. Something approaching a sense of taste has been imagined present, particularly in the antennæ or feelers. If the faculty of hearing seems occasionally exercised, we must attribute the circumstance in part to the perception of the disturbing cause by vision, and in part to the vibrations produced in the liquid.

The visual organs (XXXVIII. 16–19, 33) have claimed particular attention, and now have their existence in the majority of Rotatoria, at some period of their life, satisfactorily proved. Dujardin, dissatisfied with Ehrenberg's hasty generalizations, and compelled to deny the visual character of the coloured specks in various Protozoa and Phytozoa, looked, no doubt, with greater scepticism upon the Berlin Professor's representations of eyes in Rotatoria than he otherwise would have done, and started some objections against them. He says—"I will not deny a certain analogy between the red specks and the coloured points observed in *Cyclopidæ*, and which may be called eyes; but I cannot assign to such specks a very high importance, seeing that they constantly disappear in the adult condition of many Rotifera, and otherwise show themselves more distinctly, according to the degree of development as determined by the season and the place of development." It should be noted, however, in reply to this objection, that a similar disappearance, on the attainment of the adult state, occurs in the parasitic Crustacea, the visual character of whose eye-specks or ocelli is not questioned. Moreover, although some coloured specks in the Rotifera are undoubtedly mere heaps of granules, yet others have assuredly a definite optical organization and function. These possess a refracting medium, the essential part of an eye; and their organization, though simple and imperfect, yet elevates them to the rank of eyes, eyelets, or ocelli.

Ehrenberg gave much attention to the position, number, and other peculiarities of the eye-specks of Rotatoria, as he employed them largely in framing his classification. Unfortunately, however, he did not acquaint himself sufficiently with their minute structure, but was content to call all the coloured specks he met with eyes, and insisted on unimportant and inconstant particulars as generic and specific characteristics. These errors have consequently much vitiated his classification (*see* chapter on Classification); and the tendency at the present day is to assign to the coloured eye-spots an altogether secondary rank among the characteristics of Rotatoria.

Ehrenberg described the eye-specks as variously situated, on the fore part of the head (forehead) or on the neck, as mostly sessile (*i. e.* situated immediately on the part), and rarely pedunculate (*i. e.* supported on a pedicle or stem), as in *Otoglena*. In some species, as in *Rotifer*, the eyes are placed on a protrusile part of the head, and consequently appear at one time in advance of the head, and at another far backward within the body. In *Monura*, Ehrenberg states they are moveable. The number of eye-spots varies considerably: in several genera there is but one, *e. g. Furcularia, Monocerca, Notommata*, and *Brachionus*; but two eyes are more common, as in *Melicerta* (XXXVII. 15), *Lacinularia, Megalotrocha* (XXXII. 376), *Rotifer* (XXXV. 476–478), and *Diglena*; three eye-specks occur in *Asplanchna, Triophthalmus* (XXXIII. 412–414), *Eosphora*, and *Otoglena*; four in *Squamella*; and from six to twelve coloured spots and upwards are met with in *Cycloglena* and *Theorus* (XXXIV. 425–429), but their visual character is more than doubtful. These last "conglomerate eyes," as Ehrenberg calls them, appear to be no other than collections of coloured (it may be oil) particles, and are akin to the large coloured spaces seen on *Notommata forcipata* and *Synchæta Baltica*, having neither a definite nor a regular outline (see p. 440). Subsequent research has proved Ehrenberg in error respecting the number of eyes in several species,—an error which seriously affects his classification.

The ordinary colour of the eye-specks is red, but sometimes it is reddish-brown, and rarely violet or black. The colour may change in the lifetime of the individual, as from red in the young to black in the adult state. In a few instances no eye-specks are visible.

Except some of the doubtful collections of coloured specks, the eye-spots are placed immediately above the great ganglion of the head, the homologue of the brain, or, as Siebold affirms, are united with it by intermediate nerve-fibres. The intimate structure of the eyes was ill-understood by the great Prussian Professor. He was unable to convince himself of the existence of a crystalline lens and of a cornea. Thus, in his account of *Rotifer vulgaris*, he states that the eyes consist of several cells filled with a granular pigment, and sometimes they separate abnormally into several portions. He thinks there is no crystalline lens, although they are probably compound, like the eyes of insects.

Siebold insisted on the coloured specks of Rotatoria being sharply defined, and in many cases, at least, furnished with a capsule, in contradistinction to the ill-defined vanishing pigment-masses imagined to be eyes in the Protozoa. Wagner also speaks of a lens in the eyes of *Lacinularia*. Perty is adverse to the notion of a lens or cornea, or of a capsule; yet in *Pterodina Patina* he notes that the elliptical eye-speck, viewed on the side and from below, is seen to consist of an upper red and an under white half. That the latter represents a refracting medium is highly probable. A compound structure is further indicated by Perty in *Scaridium longicaudum*, in which he perceived "a mass of small granules resembling a gland, in the midst of the red pigment-corpuscles, which are outspread irregularly, and paler at the circumference. Moreover, in *Euchlanis triquetra* there is an irregular brown scale with reddish-brown contents, whilst in *E. Luna* the unusually large eye-spot appears to be made up of ten to twelve distinct red granules.

Leydig arranges the single eye-specks under three types:—1. an ordinary pigment-spot, of a rounded or irregular outline, a reddish-brown, black, or violet colour, not sharply defined, *e. g.* in *Notommata Synchæta*; 2. a defined, sharply-bounded speck, actually composed of two coalesced hemispherical portions, such is seen in *Brachionus*; 3. a speck having a clear refracting body projecting from the mass of pigment—a structure discovered by Leydig in *Euchlanis unisetata* (XXXVIII. 19). The first type is the most prevalent.

Leydig next proceeds to show that the single eye-specks, appearing only as an accumulation of pigment-granules, are precisely homologous structures with the reputed eyes of *Cyclops* and *Daphnia* among the Entomostraca, and of *Argulus, Artemia,* and *Branchipus* among the Phyllopoda. In neither the one nor the other does a lens, cornea, or capsule exist, although in a few (for instance, in *Notommata Myrmeleo*) a glistening white substance is intermixed. The single eye-spot of *Brachionus*, with its coalesced central segments, has its counterpart in the eye of the larva of *Cyclops*, and an evident analogy with that of *Cyclopsina*, as also with that of *Caligus*, in both which a refracting lens makes its appearance, it is likewise similar in general conformation.

Who then, asks Leydig, can advance any direct arguments against the hypothesis that, by the medium of the pigment-granules in immediate contiguity with the nerve-cells of the brain, without a refracting body, a perception of light is possible? That the Rotatoria, on the contrary, may possess, equally with the Crustacea, a refracting medium, is illustrated by the example of *Euchlanis unisetata.* With reference to those species having two eyes, Leydig has convinced himself of the presence of a lens in both in *Pterodina, Stephanops, Metopidia, Rotifer citrinus*, and in *R. macrurus*; and he thinks he has seen one in the eyes of the young of *Tubicolaria, Melicerta*, and *Stephanoceros*, although the soft state of the parts and their indistinct outline render the observation less certain. In the last-cited animals, when any trace of the eye-pigment remains, none whatever of the crystalline lens is visible. Of the other binocular Rotatoria, not mentioned, Leydig's opinion is, that analogy intimates the existence of a refracting medium, and their nature as true eyes. The presence of a special horny skin or a particular capsule surrounding the pigment is doubtful; for the cuticle probably performs the office of a cornea.

Of the many-eyed Rotatoria, Leydig has particularly examined *Eosphora* and *Theorus.* He finds Ehrenberg in error respecting *Eosphora*, which, in fact, possesses a single eye-speck above the brain; and what that naturalist took to be two clear eye-points on the frontal margin are merely intensely orange- or yellow-coloured spaces, which are at once seen to be without any affinity with the other eye-specks. The eyes of *Theorus* are nothing more than oil-drops within the stomach-glands. Ehrenberg, moreover, describes colourless eyes, the visual nature of which may well be doubted. Although he has no direct observation, Leydig believes that in *Squamella* the pigment is composed of numerous portions disposed around a crystalline lens, and that the animal may consequently be called many-eyed.

The conclusions arrived at by Leydig are, "that the single-eyed species of Rotatoria have, many of them, a refracting body in their eye-specks, which are therefore true simple eyes, but that in most cases a lens is wanting, and the specks are merely rudimentary eyes; whilst in those with two eye spots, each of them is, by the presence of a lens, an actual simple eye."

Ehrenberg stated that eye-specks were entirely absent in several genera: such were the doubtful Rotatoria *Ptygura* and *Ichthydium*, also *Chætonotus, Cyphonautes, Tubicolaria, Enteroplea, Hydatina, Pleurotrocha, Lepadella, Hydrias, Typhlina,* and *Noteus.* With reference to *Tubicolaria*, Leydig shows that in the young state this genus has two eye-specks; of the other exceptional forms, several have been insufficiently examined to found any certain statements upon.

The curious fact of the disappearance of the eye-spots in several Rotatoria has been already referred to. Examples occur in the genera *Melicerta, Lacinularia, Floscularia, Tubicolaria,* and *Megalotrocha.*

c. *The Psychical Endowments* of Rotatoria are probably of the nature of instinct; some so supposed are simply acts dictated by external circumstances. Perty intimates that the apparent sinking after one another, the gamboling among themselves, and the fact of their depositing their eggs in chosen and appropriate localities, to which, after an absence, they will return, are phenomena evidencing perception, design, and a sense of company. This last imagined sense was one suggested by Ehrenberg, who affirmed that he had observed it in the case of *Philodina roseola*, which, when kept in glasses, deposited its eggs in heaps, the parent remaining a long time with the young ones produced from them, and so constituting a sort of family or colony,—an act dictated, as he surmised, by a sense of company or family.

The occasionally-observed rejection, and ejection, of what may be deemed disagreeable or unsuitable nutriment, are acts which some might interpret to be indicative of volition, and, in some degree, of pain or unpleasant impression; but they are quite explicable without reference to a sentient nerve-centre, or to high psychical endowments. The same thing may be said of other reputed evidences of the existence of psychical or mental faculties.

Of the Reproductive Organs and Development of Rotatoria.—The Rotatoria were for a long time assumed to be hermaphrodite or monœcious, *i. e.* that each individual possessed a perfect male and female reproductive apparatus, by which ova are formed, and fructified without the presence or contact of any other individual. There has never been any difficulty in determining the female generative organs, which are very clear and well defined; but the greatest diversity of opinion has subsisted respecting the coexistence of male and female organs in the same individual.

Dujardin attempted no explanation of this matter, whilst Siebold candidly affirmed that in the absence of any precise knowledge as to the male organs, it is impossible to say whether the Rotatoria are monœcious, or have the sexes separate—are diœcious.

The clearing up of this *questio vexata*, in several at least of the Rotatoria, is due to our countryman Mr. Brightwell of Norwich, who demonstrated the existence of distinct male animals, and figured them (XII. 65, 66) in his 'Fauna Infusoria.' This discovery was further carried out by Mr. Dalrymple, and has subsequently been extended by Mr. Gosse, Leydig, and others. Inasmuch, however, as the monœcious or hermaphrodite condition is very prevalent among the lower Invertebrata; as the males of the majority of the Rotatoria have as yet escaped detection; and as there are parts discernible in several of them presenting some similarity with recognized male organs in other animals, not a few eminent observers still incline to the belief that, at least in a portion of this class, the sexual organization is of the monœcious type. These doubtful organs will be discussed after the well-determined female apparatus, and the male animals, have been described.

Female Reproductive Organs.—These were pretty accurately determined by Ehrenberg, who noticed a single or double ovary, an oviduct, an ovisac, and a vaginal sheath or outlet leading to the cloaca or the rectum.

The ovary, in which the ova or eggs are generated, lies immediately beneath or behind the alimentary canal, between it and the contractile sac (XXXVIII. 26 *o*, *p*; XXXVII. 1 *e*, 19 *h*, 32 *c*); its anterior border often advances as far forward as the maxillary (œsophageal) head. Oftentimes its position is rather transverse, and it lies across the intestine, or is curved to some extent around it. It varies in size, but is always a very large organ, and occupies a considerable space in the interior of the body. It also presents much diversity of figure, being sometimes round, oblong, or oval, at others flattened, elongated, reniform, bilobed, horned, or curved like a horse-shoe. It is enveloped by a delicate membrane, rendered very obvious by the action of acetic acid

(XXXVII. 220), which contracts the substance of the ovary, and throws the membrane into sharp folds. This membrane may likewise be detected without the assistance of chemical reagents, where it is contracted below into an outlet or duct opening in the cloaca. It forms a pellucid membranous bag, which may be ruptured by pressure, giving exit to its viscid contents; and Leydig asserts that the wall of the ovary is contractile, as the addition of alcohol demonstrates.

The substance of the ovary is called the '*stroma*' or protoplasm; it has a finely-granular appearance and a viscid consistence. It is usually of a milky or a light-grey colour, and has interspersed in it, besides granules, numerous clear bodies of a vesicular appearance (XXXVII. 1 *e*; XXXVII. 7), but which, Leydig says, are really homogeneous. Williamson counted between 20 and 30 in the ovary of *Melicerta*, varying in diameter from $\frac{1}{1200}$th to $\frac{1}{1600}$th of an inch (XXXVII. 22). These, by development, constitute the ova or eggs, and may be termed rudimentary ova. Within each a finely-molecular, more or less opaque, and rounded body is perceptible (the *nucleus*), surrounded by a clear, transparent ring, apparently filled with fluid (the germinal vesicle) (XXVII. 6, 7). "These are," writes Huxley, "the germinal vesicles and spots of the future ova. Acetic acid, in contracting the pale substance, groups it round these vesicles, without, however, breaking it up into separate masses. It renders the nuclei more evident." This author further remarks, "the pale clear space is sometimes seen to be limited by a distinct membrane." The measurements of the nuclei in *Melicerta* are, according to Williamson, from $\frac{1}{3500}$th to $\frac{1}{1800}$th of an inch in diameter. Within each nucleus are usually from one to three clear spots—the nucleoli. The nucleolus, as understood by Williamson, corresponds with the nucleus in the preceding description, whilst this last term is applied by Huxley to the entire germinal body or rudimentary ovum.

FORMATION OF OVA, THEIR EXTRUSION, AND DEVELOPMENT.—After fructification, and preparatory to their transition into ova, the germinal spaces undergo various changes in constitution and appearance. The germinal vesicle enlarges, its nucleus disappears, and the ovum is indicated only by an ill-defined transparent spot, which may, by pressure, be isolated as "a small spherical cell about $\frac{1}{1000}$th of an inch in diameter, having very thin pellucid walls, and scarcely any visible cell-contents" (Williamson). Consentaneously with these movements in the germinal space, the construction of the ovum proceeds by the attraction and separation of a portion of the surrounding protoplasm forming a yelk. The portion so appropriated is particularly rich in granules which have previously congregated in the ovary, and now attracted, it may be supposed, by the active vital action set up in the rudimentary ovum. This abundance of granules produces a deeper colour and an increased opacity in this portion of the ovary; so that when, as Prof. Williamson remarks in the instance of *Melicerta*, this process of development proceeds in the centre of the ovary, the latter organ appears divided by the incipient ovum into an upper and a lower half.

The consequence of these several changes is that the resultant ovum is of considerable size (XXXVII. 170) and stands prominently outward from the general surface of the ovary, acquiring at the same time an independent character by the production of a limiting membrane about the vitellus or yelk, called the vitelline or vitellary membrane. Huxley, indeed, does not regard this as a distinct and specially produced covering, but as derived from a portion of the enclosing membrane of the ovary, pinched off from the rest.

Prof. Williamson enters into a comparison of the development of the ova of *Melicerta* with that of the higher Mammalia, to show the close relationship that subsists between them during this process. We have not space to follow out this piece of comparative physiology in the words of the author, but can only state his conclusions: viz. that the elements which are contained in and solely occupy the ovisac of the *Melicerta*, are those which, in the ovaries of the higher Mammalia, are restricted to the interiors of the Graafian vesicles; that, whilst in the former the protoplasmic stock forms one undivided mass from which portions are successively pinched off to form the ova, in the latter (the Mammalia) it is divided into small portions, each being contained within a special receptacle or Graafian vesicle, the interspaces being occupied by the stroma or tissue of the ovary.

It is in the yelk-matter, derived from the protoplasm, that the red tint noticed by Ehrenberg and others occurs; the colour depends on red elementary granules, and on highly refractive oil-like particles. Mr. Gosse suggests that "possibly the colouring matter of these reservoirs may be resolved into the red pigment of the eyes, and the yellow of the jaw-cushion and other parts;" such a destiny we deem scarcely probable. Moreover the appearance of oil-molecules often refracting a red colour, about parts in which active development is proceeding, is a fact very generally observed. A red hue of the ova is seen in *Philodina roseola*, *Brachionus rubens*, *Mastigocerca carinata* and *Polyarthra*; in *Notommata Sieboldii*, *Asplancha*, *Anuræa curvicornis*, *Synchæta pectinata*, and in *Lacinularia socialis*. Leydig believes that in many forms, *e. g.* *Brachionus*, *Noteus*, and *Euchlanis*, one portion of the ovary produces almost exclusively the yelk, and has in consequence a darker colour than the other part, which developes the germinal spaces. This phenomenon has, he remarks, its analogue in various Crustaceans—the *Hexapoda* and *Asellina*. It may be here stated, however, that the darker portion of the ovary has assigned to it, by other naturalists, the office of preparing the winter ova, presently described, rather than the yelk, as supposed by Leydig. The preceding account, indeed, applies particularly to the production of the ordinary ova; the early history of the winter ova referred to will be given in the account of development.

The Ova.—The Rotatoria develope two varieties of eggs, called respectively "summer" and "winter" ova, besides male eggs. Much difference obtains between them, especially in their developments, contents, and later history. The summer eggs have thin, smooth, firm, and elastic shells, so transparent that the course of the changes proceeding within may be watched throughout. In figure they are ellipsoid, oval, or ovoid (XXXVII. 5, 6, 8, 9). They are laid by the animals during the whole course of the summer, and are forthwith hatched. The winter ova, on the contrary, are chiefly produced in the autumn, and are destined to remain in an inactive or torpid state during the winter. They are generally of larger dimensions, often irregular in form, from inequality of the two sides, or from prominences or depressions of the surfaces (XXXIX. 20), and opaque on account of their dark granular contents and of their double shell (XXXVII. 21, 22, 24). Caustic potash renders the shells clearer and more transparent, and causes some of the inequalities of their surface to decrease. Huxley says that the tough elastic membrane or shell is soluble in both hot nitric acid and caustic potassa. Between the two shells is an interspace, more roomy, at the opposite ends of the egg. The inner shell is thin and delicate, and immediately envelopes the yelk enclosed in its vitelline membrane. The external one is thicker, firmer, and usually of a brownish-yellow colour. Its surface is mostly roughened, or tuberculated, striated, or thrown into ridges, areolated, cellular, or divided into facets, beset with longer or shorter hairs and bristles, and occasionally with spines. Examples of such modifications of the surface occur in

Anuræa Testudo, A. serrulata, Notommata Sieboldii, N. Myrmeleo, Melicerta ringens, Ascomorpha Germanica, Lacinularia socialis, Scaridium longicaudum, Hydatina senta, Anuræa valga, &c. Ehrenberg was not prepared to admit the existence on ova of actual hairy processes, but supposed them to be the hair-like filaments of Hygrocrocis, or of other Algæ. This supposition may in some cases be correct; for ova, like other bodies in the water, may become the nidus for the growth of various microscopic plants and animals. That some ova, however, are actually hairy is evidenced by their visible occurrence in that state even whilst still within the abdomen of the parent; as may be seen in the ova of *Hydatina senta*, of *Notommata Parasitus*, &c. Both winter and summer ova may often be met with in the same animal (XXXIX. 16)—the one kind perhaps still in the ovary, the other on the point of expulsion; or, it may be, both sorts may be carried about attached to the posterior part of the parent animal. This last occurrence is noticed by Leydig in *Brachionus Bakeri*.

These two varieties of ova were recognized by Ehrenberg, who assigned them the names applied to them. Mr. Huxley suggests, instead of the term 'winter ova,' the appellation, 'ephippial' ova, to indicate their analogy with the similar eggs of *Daphnia* and other Entomostraca.

When recounting the propagation of *Notommata Sieboldii*, Leydig remarks that male and female ova are not developed together in the same animal. This fact has been extended by Cohn to apply to the whole family of Rotatoria. According to him the ephippial are always distinguishable by their external characters from the common summer ova, particularly by their much smaller dimensions. They have thin, transparent shells, and are chiefly produced at those seasons when 'ephippial' ova are generated. Their development follows the same course as that of the 'summer' ova; but they are produced in very much smaller numbers,—a circumstance that affords another reason for the paucity of males compared with females, whenever a collection of Rotatoria is examined.

When the development of summer ova in the ovary has proceeded to the point we have mentioned, and the egg is already become a distinct body from the general substance of the ovary (XXXVII. 2 *d*), it is slowly moved downwards towards the passage or oviduct (XXXVII. 2 *f*), which ends in the cloaca (XXXVII. 32 *d*); and it is in this part of its course that the shell becomes perfected. In the majority of the Rotatoria the ova are at this stage extruded, the further phases of development proceeding externally to the animal; in others they are detained in their passage until the embryo is more fully elaborated, or even until it is perfect and released from its shell.

The size of the ova prior to expulsion XXXVII. 32 *d*; XXXVIII. 26 *p*) is very extraordinary, so much so that a single ovum will sometimes occupy the larger portion of the interior of the animal. The completed egg of *Melicerta* has an average length, says Williamson, of $\frac{1}{150}$th of an inch, and a diameter of $\frac{1}{250}$th. The eggs of some *Hydatinæ* are $\frac{1}{236}$th, of *Lacinularia* $\frac{1}{450}$th of an inch and upwards in diameter.

In several Rotatoria, two or more ova become agglutinated together near the termination of the oviduct, or in the cloaca, and are expelled together *en masse*, and still remain adherent to the parent, close to the cloacal outlet at the base of the tail. This is exemplified in *Triarthra* (XXXVIII. 30 *d*), *Polyarthra* (XXXIII. 400, 401), *Anuræa* (XXXV. 496; XXXIX. 16), and *Noteus*.

The oviduct, or passage from the ovary to the cloaca, is a membranous tube formed by a prolongation of the tunic of the ovary. It is always extremely dilatable; and sometimes an egg is so long detained in its lower part, that it seems to serve the purpose of a uterus, and has received the name of *ovisac*. The orifice of this oviduct or ovisac into the cloaca is called the "vaginal orifice;" the vaginal sheath, spoken of by Ehrenberg, would appear to be either the termination of the oviduct or sometimes the cloaca itself. The oviduct may occasionally be deficient. Prof. Huxley states that he could discover no such passage in *Lacinularia*.

The egg, having descended into the cloaca, is expelled thence by means of a strong contraction of the whole body, and, in the act of escaping, involves the eversion of the cloaca. The time occupied in the formation of the summer egg, from its first appearance as a vesicular space in the ovary to its completion and extrusion, is very brief, generally only a few hours.

We have noted the discharge of several eggs adherent together, and their subsequent attachment at the anal outlet. In other Rotatoria, likewise, ova expelled singly attach themselves at the posterior extremity of the body, singly or united together by a gelatinous matter, and not uncommonly attached by evident cords or pedicles to the parent. This is seen in *Megalotrocha*, in *Brachionus rubens*, and in *B. Pala*.

In the species last named, as many as ten may often be seen in a group near the cloacal orifice. In *Ascomorpha*, some six may be found adherent. In *Polyarthra* (XXXVIII. 30), not more than one egg is found attached at the same time. Thus the eggs are carried about by the parent one after another, arriving at maturity and escaping from its shell. The like phenomenon is seen in various Entomostraca, and in *Polynoë*, *Exogona*, and other Vermes, which likewise produce both summer and winter ova. Among the urceolate Rotifers, the eggs escape into the case or gelatinous investment, and there proceed to their ultimate development, safe from many obnoxious influences and from destruction by other animals.

Development of the Embryo.—The following changes transpire preparatory to the construction of the embryo. The nucleus is seen to elongate, and then to present a constriction about its middle (XXXVII. 5); the yelk at the same time shows a similar constriction, which continues to deepen in correspondence with that of the nucleus, until at length there are two segments, each with its contained nucleus—the result of the fission of the primary one. Leydig states that this division is not into two equal portions, but that a segment is cut off from one end or pole (XXXVII. 2 *b*), and that in the continued segmentation which ensues, this same unequal fission is again and again repeated. However this may be, the act of division goes on (XXXVII. 8) until at length the whole yelk is broken up into a mass of minute cells, and its opacity increased by the number of molecules they contain (XXXVII. 2 *c*, *g*). Out of this mass, the tissues and organs of the embryo are developed, appearing in their characteristic forms without any, or otherwise very slight, transitional phases (XXXVII. 2 *e*, *d*; XXXVIII. 9). It is characteristic also of Rotatoria, in common with all the Vermes, that the embryo is generated from the entire yelk, and not, as in Crustacea and still higher animals, from an accessory body superposed upon the yelk, into which the yelk is gradually taken up. Dr. Carpenter remarks that the mode of development is in all essential respects the same as that of the Nematoid Entozoa, each group of cells evolving some one principal organ.

The order of succession of the parts of the embryo in the egg is thus described by Ehrenberg in the instance of the *Megalotrocha albo-flavicans*:—"A turbid central spot appears, which becomes the œsophageal bulb and teeth; a blackish granular oval body is also seen posteriorly; the eyes gradually become red, and a motion of the cilia of the head is visible; after some hours the whole fœtus, which is folded up, turns itself round, the shell bursts, and the young animal creeps out." In a specimen of *Brachionus Bakeri* the first thing Mr. Brightwell detected was a motion like that of the muscular œsophagus of the parent.

The best account we have of the subject is that given by Prof. Williamson of the *Melicerta ringens*:—"The first trace," he says, "of future organization which presents itself, appears in the form of a few freely moving cilia ....at two points, one of which corresponds with the future head, the other near the centre of the ovum....with the cavity of the stomach; shortly after....traces of the central parts of the dental apparatus present themselves, this, again, being soon succeeded by the union of the entire mass of yolk-cells, and the formation from them of the various organs of the animal. The cilia now play very freely, especially at the head. The creature twists itself about in its shell; two red spots appear near the head, which Ehrenberg regards as organs of vision, and along with them a very dark-brown and somewhat larger spot is developed in the integument near the lower stomach. The young animal now bursts its shell;....and although its external appendages (XXXVII. 15), and especially the rotatory organs are imperfectly developed or unexpanded, yet the whole of its internal organization, though but obscurely seen, is nevertheless that of the perfect animal, and not that of the larval state."

In the embryo animal, whilst within the egg (XXXVII. 2 *k*), as well as for a short time after its escape (XXXVII. 3, 4 *b*), Leydig finds in most Rotatoria the collection of black or dark-brown particles close upon the cloaca (XXXVIII. 7, 8, 9), which has been described in the section on Secretion, as a supposed mass of urinary concretions.

The period occupied in the development of the embryo differs in different species. Ehrenberg stated that in *Hydatina senta*, eleven hours after the deposition of a complete ovum, vibration of the anterior cilia was visible, and in 24 hours the young being escaped from its shell. Mr. Brightwell, in his notice of *Brachionus Bakeri*, states that "about 2 o'clock the animal was observed with one egg placed externally between the two posterior spines of the shell, and another small egg in the left side of the animal, which increased much in size in the course of the day; at 9 in the evening a motion was perceived in the exterior egg like that of the muscular œsophagus of the parent; and about this time the internal egg was protruded and placed by the side of the other, being longer than it. At 11 the young *Brachionus* burst with a bound from the egg in which the motion was perceived, and affixed itself by its tail."

The egg-shell splits open, longitudinally or transversely, to give exit to the young animal. This seems brought about by the active movements of the embryo itself, which sometimes bursts (as Brightwell says) with a bound or spring from its prison. Where the eggs have been attached, the empty fissured shell continues still adherent for a time, until by the movements of the parent, or by some accident, it is detached.

The variation among different Rotatoria in the stage of development in which the ovum is found when it quits the ovary, or when it is expelled from the body, has been already remarked; but additional illustrations are desirable. In the greater number, the egg is laid just before or very soon after the process of segmentation of the yelk commences; for example, in *Melicerta, Lacinularia,* and *Brachionus.* In many genera the ovum continues in the oviduct, the ovisac, or the cloaca, or otherwise remains within the ovary itself until the embryo is complete and even free. Examples of this are found in *Stephanoceros, Actinurus,* in *Rotifer,* and in *Notommata Syrinx, N. Sieboldii,* and in *Asplanchna.* In *Rotifer,* Ehrenberg remarks that, in the ovarium, four or five ova sometimes so completely develope themselves, that the young creep out of their envelopes, in which they were coiled up in a spiral manner, extend themselves, and put their wheels into motion while within it; and they sometimes occupy two-thirds of the bulk of the parent. So Mr. Gosse tells us that in *Asplanchna* "the ovum produces the living young in the ovisac, which, when matured, occupies the whole lower part of the parent." The occurrence of embryos free within the saccular ovary of *Stephanoceros* (and still more, if as some have thought, they detected them loose in the general cavity of the body) forms another bond of affinity between this aberrant genus of Rotatoria and the Bryozoa. Where the young in general quit the parent in a free, and so far perfect form as to be able to lead at once an independent existence, the animals may be said to be viviparous (producers of living young). This viviparousness (viviparity) is still more pronounced in some *Philodinæa* and in *Albertia*, in which the formation of an actual egg-shell seems to be omitted, and the developed embryo to be at once liberated within the sac of the ovary, where it may be seen in active movement.

THE EMBRYO METAMORPHOSIS.—It has already been remarked, generally, that the embryo on emerging from the egg has all the characters of its class, and is complete in its internal organization; that any dissimilarity between the new-born and the adult animal is due, not to the absence of parts or organs, but to their lesser growth and their imperfect expansion or evolution. In other words, the Rotatoria undergo no positive metamorphosis; they pass through no intermediate phases of existence, no larval form resembling that of any Protozoa, in advancing from the embryonic to the complete and perfect condition.

Leydig does not partake this opinion, but thinks that a metamorphosis is exhibited in the course of development of most or all Rotatoria, certainly not complete, but still sufficient to advance it as a phenomenon of the class. He specially adduces the instance of the embryo of *Stephanoceros*, as the most striking proof (XXXVII. 3, 4), and he adds that, if the representation by Ehrenberg of the young of *Triarthra longiseta* be correct, the fact of a metamorphosis must be recognized also in that genus. Again, he notes the great difference between the newly-born and the adult animals in several genera, *e. g.* in *Tubicolaria* and *Melicerta*, where the ciliary wreath is still very simple, and the absence of the tentacles (antennæ) sufficiently notable (XXXVII. 15) to render the subsequent modifications an act of metamorphosis. Moreover, the disappearance of the bunch of cilia in the young state at the end of the pseudopodium, and likewise that of the coloured eye-specks in many genera, when the adult condition is attained, are also indications of the same phenomenon.

The advocacy of this opinion was especially incumbent upon Leydig, in order to furnish an additional argument in favour of the affinity of the Rotatoria with the Crustacea. But even were the evidences of metamorphosis among the Rotifera as complete as he represents, they would serve his purpose, of demonstrating the affinity he advocates, but little, seeing that the immature Rotatoria have no real resemblance to the larval Crustaceans with their three pairs of jointed feet. Cohn (Siebold's *Zeitschr.* 1855, p. 481) has discussed this question, and surmises that the peculiar embryo of *Stephanoceros*, which Leydig cites as the strongest instance of an act of metamorphosis, is a male being (XXXVII. 3). As to the other supposed instances, Cohn disproves its occurrence in *Brachionus*, and considers the disappearance of the eye-speck in *Tubicolaria* and *Melicerta* too trivial a circumstance to urge in its support.

Perty seems struck by the considerable variations in form between many embryo and adult Rotatoria, and enunciates the opinion that many supposed perfect forms are no other than embryonic conditions,—for example, *Glenophora Trochus, Monocerca valga, Notommata Felis, and Cycloglena elegans.* We do not understand whether he believes in a metamorphosis, or if he would simply state that Ehrenberg unnecessarily multiplied genera and species by describing immature beings as distinct forms. If the latter be all that Perty intends, we entirely concur with him.

It is necessary to detail the form and structure of some embryo Rotifera, to illustrate the preceding statements. The embryo of *Stephanoceros* (XXXVII. 3, 4) is thus described by Leydig:—" It has in general a vermicular figure. The head, which supports the eyes, is separated from the trunk by a well-marked constriction, and is furnished with long cilia. The head and cilia are retractile. The red specks (two in number) appear actually to be of the nature of eyes; they have a sharp outline and are slightly concave in front, as if a refracting body was there seated. Within the abdominal cavity behind the head, a peculiar striation is observable, the purpose of which I cannot imagine; further backward is a clear space in which long cilia are seen in activity, and which indicates the cavity of the alimentary canal. Moreover, the maxillary apparatus, and the special vesicle containing the inorganic particles (urinary concretions) are perceptible. The termination of the body bears some delicate vibratile cilia." Beyond this phase of development, the embryo does not advance in the egg, but after being hatched, it would seem to assume another intermediate form before arriving at the adult state. Leydig found, in water containing *Stephanoceros*, a young animal still possessing in some measure the previous vermiform figure and apparent articulation of the trunk and foot, and a proboscis-like head with four projecting arms. The eye-specks were still present. From the trunk-like process of the head, two considerable tubular appendages were outstretched, ciliated at the extremities: the cilia on the end of the foot-process had disappeared, but were very evident in the abdomen, near to the sac containing the inorganic particles. The mandibular apparatus had the regular structure. He frequently encountered also another variety, which, together with the figure of the perfect animal, had five arms, but was without any apparent sexual organs, while the foot-process and the whole body were strewn with numerous fat-globules.

We will now continue the description (see p. 446), by Prof. Williamson, of the embryo of *Melicerta* after escaping the egg-shell. He writes—" The young *Melicerta* stretches itself out, and, everting the anterior part of its body, unfolds several small projecting mammillæ covered with large cilia, by means of which it floats freely away (XXXVII. 15, 16). These mammillæ are in this stage not unlike those of *Notommata clavulata*, but they soon enlarge and become developed into the flabelliform wheel organs of the mature animals. The dental apparatus is now fully developed; the alimentary canal and muscular fasciculi are all present,—only the epithelial cells of the former have not as yet obtained their yellow granular contents; consequently the viscera exhibit the same hyaline aspect as the rest of the organism. The two red specks are imbedded in two of the mammillæ. After swimming about for some time like other free Rotifera, the animal undergoes further changes. The dark-brown spot is the first to disappear; and soon after, the two pink ones cease to be visible. The animal attaches itself by the tail to some fixed support, and developes from the skin of the posterior portion of its body a thin hyaline cylinder, the dilated extremity of which is attached to the supporting object. The formation of the case is now begun; the first-formed spheroidal or tentacular particles are arranged in a ring round the middle of the body, and appear to have some internal connexion with the thin membranous cylinder. At first, new additions are made to both extremities of the enlarging ring; but the jerking contractions of the animal at length force the caudal end of the cylinder down upon the leaf, to which it becomes securely cemented by the same viscous secretion as causes the little spheres to cohere. All the new additions are now made to the free extremity, which, as Ehrenberg remarks, never extends beyond the level of the cloacal aperture of the outstretched animal. In the new-born being, therefore, the parts, as in the adult, are all present; they only require to be expanded by the ordinary process of growth."

Mr. Gosse's account of a newly-hatched *Melicerta* implies a greater aberration of form than that narrated by Prof. Williamson. He states that "its form is trumpet-shaped like that of *Stentor*, with a wreath of cilia around the head, interrupted at two opposite points. The central portion of the head rises into a low cone." After various movements and gyrations for an hour, the young animal settled itself, and the form of the adult became manifest: "the four petals of the disk were well made out, though the sinuosities were yet shallow; the antennæ at first were only small square nipples, but soon shot out into the usual form; the ciliated chin was distinct, as was also the whirling of the pellet-cup immediately beneath it."

We are indebted to Mr. Huxley for an elaborate description of the young of *Lacinularia socialis* (XXXVII. 10, 11). "The youngest fœtuses," he writes, "are about $\frac{1}{70}$th of an inch in length. The head is abruptly truncated, and separated by a constriction from the body; a sudden narrowing separates the other extremity of the body from the peduncle, which is exceedingly short and provided with a ciliated cavity, a sort of sucker, at its extremity. The head is nearly circular seen from above, and presents a central protuberance, in which the two eye-spots are situated. The margins of this protuberance are provided with long cilia; it will become the upper circlet of cilia in the adult. The margin of the head projects beyond this, and is fringed with a circlet of shorter cilia in the adult. The internal organs are perceived with difficulty; but the three divisions of the alimentary canal, which is as yet straight and terminates in a transparent cloaca, may be readily made out. The water-vascular canals cannot be seen; but their presence is indicated by the movement of their contained cilia here and there.

"In young *Lacinulariæ* $\frac{1}{30}$th of an inch in length, the head has become triangular; the peduncle is much elongated, and it gradually takes on the perfect form. The young had previously crept about in the gelatinous investment of the parents; they now begin to "swarm," uniting together by their caudal extremities, and are readily pressed out as united, free, swimming colonies, resembling in this state the genus *Conochilus*."

Mr. Brightwell gives the appended brief account of the *Brachionus Bakeri* on its escape from the egg:—"At first it had the appearance of an oblong ball; by degrees the anterior part spread, and the wheel processes were developed. Soon after, the posterior shell (lorica) processes were visible in a semilunar shape, with the points nearly touching each other, which gradually expanded."

These examples are sufficient to illustrate the general character of embryo Rotatoria and their progressive assumption of the adult form; they moreover furnish evidence of the doctrine that there is no metamorphosis, or transformation, in the proper sense of the word--no change but what is explicable by the ordinary laws of growth, or progressive expansion or evolution. Ehrenberg has announced it as a fact (*Monatsb. d. Berl. Akad.* 1853, p. 532), that Rotifera found at great altitudes among snow do not attain a complete development, but retain, as he expresses it, an ovate contracted figure within an egg-like envelope or capsule, through which food reaches them by a funnel-shaped canal. All the functions of life he represents to go on as usual under these peculiar conditions of existence, including the deposition and hatching of eggs. This account reads like a description of an encysting-process in the first degree—that, viz., for self-defence and preservation—such as is illustrated in the formation of an open sheath around *Stentor*, as stated by Cohn (see p. 284).

CONTENTS AND DEVELOPMENT OF WINTER OVA.—The contents of "winter" widely differ from those of "summer" ova. Mr. Gosse gives the following account of those of *Melicerta ringens*. He writes—"Opening one or two cases (urceoli), I find one and another very curious egg-like bodies, not symmetrical in shape, being much more gibbous on one side than the opposite, and measuring $\frac{1}{150}$th by $\frac{1}{280}$th of an inch. Each was encircled by five or six raised ribs running parallel to each other longitudinally, somewhat like the varices of a wentle-trap: viewed perpendicularly to the ribs, the form is symmetrical—a long narrow oval. The whole surface between the ribs appeared punctured or granulate, and the colour was a dull-brownish yellow. Under pressure it was ruptured, and discharged an infinity of atoms, of an excessive minuteness, but every one of which for a few seconds displayed spontaneous motion. Their whole appearance, and the manner in which they presently turned to motionless disks, were exactly the same as the spermatozoa which the male eggs of other Rotifera contain, except that these were so minute."

Mr. Dalrymple describes similar peculiar ova in *Notommata* (*Asplanchna*) to consist of an aggregation of cells and of pigment-granules, without a distinguishable germinal vesicle.

The most complete and satisfactory account of the structure and development of the winter ova is supplied by Prof. Huxley in his History of *Lacinularia* (*T. M. S.* 1852, vol. i.); we will, however, preface it by Leydig's description. We learn from this writer that in winter ova, a space filled with fluid usually intervenes between the yelk at each pole or end of the egg, and the inner shell, as in *Tubicolaria*, and that, according to Weisse's observation of *Brachionus urceolaris*, the outer shell, when the embryo is ready to come forth, springs open in a valvular or a lid-like manner. The central portion of the yelk has a darker and more granular appearance, and is surrounded by a clearer peripheral or cortical lamina, as in *Brachionus Bakeri*, *Notommata Myrmeleo*, and *N. centrura*. Intermingled with the yelk-molecules are numerous clear vesicles, and oftentimes fat-particles; moreover, the yelk of *Notommata Sieboldii* has a yellowish-red colour (XXXVII. 27, 28). These "lasting ova," as Ehrenberg has otherwise named them, are always developed externally to the animal. Like the summer eggs, they are frequently carried about by the parent; it would not seem, however, that they ever accumulate in groups about the cloaca, but that mostly the egg is solitary, and that two or three are of rare occurrence. Thus in *Brachionus Bakeri* and in *Ascomorpha* never more than one is present, in *Brachionus rubens* a couple are occasionally noticed, and in *Notommata Sieboldii* the highest number seen was three.

Concerning the changes ensuing on development, Leydig states that, "on the formation of a membrane around the commencing ovum in the ovary, the peripheral portion of the yelk exhibits numerous clear spots, which recall the appearance of the small cells originating from repeated fission of the yelk of the summer ova. From this we may conclude, either that the germinal vesicle may, by repeated fission, resolve itself into numerous clear vesicles, without any further change, except that of an attendant grouping of the yelk-particles about the products from the germinal vesicle, or that perhaps the winter eggs, at their origin in the ovary, enclose a number of nuclei (germinal vesicles) unlike other ova, which never commence with more than one nucleus (germinal vesicle). If," continues Leydig, "I rightly understand Huxley, this is the manner of development of the winter eggs of *Lacinularia socialis*; and the bisection into two equal halves, which I formerly referred to fission, has, according to this writer, no relation to it."

Respecting this description, Prof. Huxley remarks that he thinks Leydig "has not observed the genesis of the ephippial ova with sufficient care, and he thence interprets their structure by supposing that they are ordinarily fecundated ova, which have undergone a peculiar method of cleavage;" and having quoted the opinion of other naturalists, he goes on to say—"it will be observed that all these authors consider the winter or ephippial ova and the ordinary ova to be essentially *identical*, only that the former have an outer case. The truth is, that they are essentially *different* structures. The true ova are single cells which have undergone a special development; the ephippial ova are aggregations of cells (in fact, larger or smaller portions—sometimes the whole of the ovary) which become enveloped in a shell and simulate true ova.

"In a fully-grown *Lacinularia* which has produced ova, the ovary or a large portion of it begins to assume a blackish tint (XXXVII. 22): the cells, with their nuclei, undergo no change; but a deposit of strongly-refracting elementary granules takes place in the pale connecting substance. Every transition may be traced, from deep-black portions to unaltered spots of the ovarium; and pressure always renders the cells, with their nuclei, visible among the granules. The investing membrane of the ovary becomes separated from the dark mass, so as to leave a space (XXXVII. 24); and the outer surface of the mass invests itself with a thick reddish membrane, which is tough, elastic, and reticulated from the presence of many minute apertures. This membrane is soluble in both hot nitric acid and caustic potassa.

"The nuclei and cells, or rather the clear spaces indicating them, are still visible upon pressure, and may be readily seen by bursting the outer coat.

"By degrees the ephippial ovum becomes lighter, until at last its colour is reddish-brown, like that of the ordinary ova; but its contents are now seen to be divided into two masses, hemispherical from mutual contact (XXXVII. 21). If this body be now crushed, it will be found that an inner, structureless membrane exists within the fenestrated membrane, and sends a partition inwards, at the line of demarcation of the two masses. The contents are precisely the same as before, viz. nuclei and elementary granules. This, indeed, may be seen through the shell without crushing the case.

"I was unable to trace the development of these ephippial ova any further. Those of *Notommata*, it appears, lasted for some months without change (Dalrymple).

"It is remarkable that in *Lacinularia* these bodies eventually, like the ephippium of *Daphnia*, contain two ovum-like masses; and there can, I think, be little doubt that the former, like the latter, are subservient to reproduction.

"There are two kinds of reproductive bodies in *Lacinularia*:—1. Bodies which resemble true ova in their origin and subsequent development, and which possess only a single vitellary membrane. 2. Bodies half as large again as the foregoing, which resemble the ephippium of *Daphnia*, like it having altogether three investments, and which do not resemble true ova, either in their origin or subsequent development; which, therefore, probably do not require fecundation, and are thence to be considered as a mode of asexual reproduction."

The multicellular character of the contents of these 'ephippial' ova, Cohn is unable to confirm. In his very valuable essay on the "Development of Rotatoria" (*Zeitschr*. 1855), this able observer has promulgated the hypothesis of the occurrence of the phenomenon of "alternation of generations," of parthenogenesis or virgin-development. A *résumé* of the reasons for this view may stand thus:—Female Rotifera lay eggs of only one sex; and winter eggs are produced only by certain females and at certain periods—contemporaneously, that is, with the generation of males: again, the males are too few to impregnate the whole of the apparent female beings, which are so largely found, and always replete with ova in course of development, at all seasons. The conclusion, therefore, forces itself upon us that the common "summer" ova are produced within the parent animal without any antecedent generative act or impregnation; that is, in other words, they are asexual products or germs. If this be true, it follows that the beings producing them are not true females, but merely asexual nurses (Ammen), furnished with a germinal mass, but destitute of a real ovary, and not demanding the action of the male for the development of its germinal elements. On the other hand, the "winter" must be considered the true ova, and the beings producing them the only true females, furnished with an ovary, to which the energy of the spermatozoa of the male is necessary. But, notwithstanding these physiological differences, the mere nurses and the actual female Rotifera are indistinguishable in structure. In illustration of this hypothesis, its analogy with what occurs in *Aphis, Daphnia*, and *Artemia*, may be quoted.

Of the rate of development of these winter eggs, we know little. Huxley's account would render it a final act, involving the sacrifice of a large, or even of the largest, part of the ovary, and consequently one which we cannot suppose capable of frequent repetition. Leydig has, indeed, an observation which, if accurate, proves a rapid reproduction of such ova by the ovary. He informs us he observed an isolated individual of *Notommata Myrmeleo* lay the solitary bristle-shelled winter ovum which its oviduct contained about 12 o'clock in the day; and on renewing his researches at 3 in the afternoon, discovered another such egg completely formed in the ovary.

This author recounts also, in his history of *Notommata Sieboldii*, the following particulars, which, if confirmed, would prove the formation, whether of winter or of summer ova, to be determinable by accidental external circumstances:—"When I kept the *Notommata* for some days in clear water containing no nutriment, the ovary shrivelled, the granular mass (yelk) altogether vanished, the germinal vesicles became simple bodies, and all such individuals produced only winter eggs."

That the Rotatoria, on the approach of winter, are likely to be placed under conditions in which food is scarce, and which are unfavourable to vigorous life, is at once admissible, and, if Leydig's observation be correct, furnishes an explanation of the generally apparent limitation of the production of winter ova to that season. Be this as it may, the winter ova must be regarded as indicating the conservative tendency of nature in providing for the continuance of the species by organisms so constructed as to endure the severity of the winter season, and to retain a dormant vitality through it, until the genial influence of spring awakens them into activity and life.

FECUNDITY OF ROTATORIA.—Although the Rotatoria are not endowed with the various faculties of reproduction possessed by the Protozoa, yet their vast increase by eggs only is astonishing. Ehrenberg wrote that he insulated a single specimen of *Hydatina senta*, and kept it in a separate vessel for eighteen days, that during this interval it laid four eggs per day, and that the young of these, at two days old, lay a like number. From these data he made an erroneous calculation, that one million individuals may be obtained from one specimen in ten days, that on the eleventh day this brood would amount to four millions, and on the twelfth day to sixteen millions.

This is the only direct observation we have met with intended to prove the remarkable fertility of the class, yet, throughout the history of the Rotifera now detailed, numerous incidental illustrations of the fact occur,—for example, the presence of several ova in different parts of the sexual apparatus, in various stages of development, and the observed rapidity of the phases of development, at least of summer ova.

The latter continue to be formed and deposited throughout the whole of the warm part of the year; and when this draws to its close, the production of the winter ova provides for the continuous propagation of the species.

Ehrenberg, in his specific descriptions, notes the number of ova he met with at the time of observation, intimating that some animals bring forward but one egg at a time, others two or several.

There is, very probably, a difference in the productiveness of various species; but differences in this respect will also occur from accidental and external circumstances, such as abundance of food, and changes of temperature.

MALE ROTATORIA AND MALE REPRODUCTIVE ORGANS. QUESTION OF MALE AND FEMALE ORGANS IN THE SAME INDIVIDUALS.

Male Rotatoria.—Few male Rotatoria have as yet been determined. Those decisively made out are those of *Asplanchna Brightwellii* (*Notommata anglica*, Dalrymple), *Asplanchna priodonta* and *A. Bowesii* (Gosse), and the *Notommata Sieboldii* (Leydig). This able German observer argues also that *Enteroplea Hydatina* is the male of *Hydatina senta*, *Notommata granularis* that of *N. Brachionus*, and *Diglena granularis* that of *Diglena catellina*. Since this was written, Cohn has pursued the inquiry, and confirmed Leydig's conjecture, that *Enteroplea Hydatina* (Ehr.) is the male of *Hydatina senta*. He has moreover discovered the males of two other species, viz. of *Brachionus urceolaris* and *Br. militaris*. Still more recently, Leydig has been able to confirm his belief of *Enteroplea Hydatina* being the male of *Hydatina senta* (*Müller's Archiv*, 1857, p. 404); and Cohn has discovered the males of *Euchlanis dilatata* and *Notommata Parasitus* (*Zeitschr.* 1858, p. 284). Meanwhile Mr. Gosse had discovered the male animals and their eggs in the undermentioned genera and species:—*Brachionus Pala*, *B. rubens*, *B. amphiceros*, *B. Bakeri*, *B. angularis*, *B. Dorcas*, *B. Mülleri*, *Sacculus viridis*, *Polyarthra platyptera*, *Synchæta tremula* (?), and in all probability *Melicerta ringens*, besides the three species of *Asplanchna* previously determined (*Phil. Trans.* 1856).

The first male discovered was that of *Asplanchna Brightwellii*, then supposed to be a species of *Notommata*, and is thus described by Mr. Brightwell (*A. N. H.* 1848, ii. p. 155):—It is "about half the size of the female, and differs from it in form, being much shorter and of a rude triangular shape. It is more difficult to detect than the female, being exceedingly transparent, and, from the emptiness of the body, appearing little more than a transparent ciliated bubble. It is very active, and occasionally puffs out the sides of its body, so as entirely to alter its form, and remains thus distended some time." There was no indication of any digestive apparatus, or of matters in course of digestion.

"At the bottom of the body, on one side, is a conspicuous round sperm-vessel or testis, in which, under a high power, spermatozoa in active vibratile motion may be seen, and at its external side a duct, closed by distinct lateral muscles. Connected with the testis is a well-defined intromittent organ, and a conspicuous passage or opening for its extension from the body of the animal. In the opposite lower angle are three small, irregularly-formed, kidney-shaped bodies, connected with an angular lobe or muscle lying beneath them. The male is also furnished with the delicate membranous plicated bag, and rudiments of the curled tubular structure, found in the female."

Besides determining the diœcious character of this Rotifer, Mr. Brightwell was also enabled to repeatedly verify the occurrence of an actual coitus occurring between the sexes, and enduring the greater part of a minute.

The male of the allied species *Asplanchna priodonta* was described by Mr. Gosse. As the description supplies additional particulars concerning the organization, we extract it entire.

Having isolated an adult female, in which the developing young seemed different from the ordinary embryos, he at length had the satisfaction of seeing two males born. "Another was produced the same evening from another parent, likewise under my eye."

"The length of these specimens (XXXVI. 7, 8) (male) was $\frac{1}{110}$th of an inch (that of the females was $\frac{1}{48}$th to $\frac{1}{42}$nd of an inch). They had a general agreement in outline with the female. But the outlet corresponding to the vagina was at the very bottom of the ventral side (XXXVI. 7, 8 *b*), which ran down to a point, while the dorsal side was rounded off. At the base of this tube was a globular sperm-sac, with a short thick penis in front, the whole nearly surrounded by a delicate glandular mass. The place of the stomach was occupied by a long sac, having a slender neck originating from the fore part of the head mass, and at the bottom broadly attached to the sperm-bag. This whole organ was filled with minute granular matter, except three or four clear globular bladders; the sperm-bag showed a structure very similar.

"The principal muscles agreed with those of the female. The tortuous threads, and their plexuses, were represented by two thickened glandular bodies, extending from the head mass to the foliaceous substance surrounding the sperm bag. . . . The three eyes were present, situated as in the female, but no trace of jaws was discernible, even on pressure, nor any crop, nor true stomach. These animals were very active, swimming rapidly about, and scarcely still an instant. On one or two occasions, I observed one of the males with a slender process protruded to a considerable length from the sexual orifice, and adhering to the glass by its tip, moving round on it as on a pivot."

Leydig admits the bisexual or diœcious nature of the Rotatoria as a general fact; and although, he says, his studies have been diverted from special researches on this matter, yet, from the descriptions and representations of others, he believes he can detect several male forms arranged in the class as distinct species.

Of the male of a new species, which he calls *Notommata Sieboldii*, but which is equally a member of the genus *Asplanchna* with "the supposed new *Notommata*" of Brightwell, he has given an elaborate description and drawings. He remarks that in all details of organization it agrees with Mr. Dalrymple's account, but, unlike the English species, differs considerably in figure from the female, especially by the presence of four pointed arms (XXXVII. 29). He remarks that "the so-called" *sperm-bag* of Dalrymple is the testicle, and what that author terms the "penis" is its duct. The figures he gives of the seminal corpuscles are not altogether distinct, although the resemblance between them and those of *Notommata Sieboldii* are unmistakeable. However, I must point out an error into which Dalrymple has fallen, in describing the linear seminal corpuscles that lie parallel to one another about the outlet of the seminal vesicle to be bundles of muscular fibres attached to the base of the penis, and acting as "*ejaculatores seminis.*"

The *Enteroplea Hydatina* (Ehr.) is, in Leydig's opinion, the male of *Hydatina senta*: the reasons for this belief briefly are, that, according to Ehrenberg's description and figures, the *Enteroplea* has neither jaws nor teeth; that its ovary is homogeneous and granular; that the animal is always smaller than *Hydatina senta*; and that among the eggs of this last-named species, those developing into embryo *Enteroplea* were intermixed. Now each and all these differential, and some of them very exceptional characters, are at once interpreted by assuming *Enteroplea* to be a male animal. Indeed, in no female perfect Rotifer are the jaws wanting, and even in very young specimens the ovary is not homogeneous, but contains many germinal vesicles or spaces. A reference to Dujardin's description and engravings adds additional weight to this opinion. This supposition has been confirmed, both by Leydig himself *Müller's Archiv*, 1857, p. 404, and *A. N. H.* 1857), and by Cohn (*Zeitschr.* 1855, p. 451), and we would refer the reader to their memoirs for an extended description of this male being. By these researches, the testicle and its contained spermatozoa, together with a male projectile organ, the absence of a digestive apparatus, and other sexual peculiarities, have been satisfactorily made out.

In the case of *Notommata granularis*, the arguments for its male character are, the absence of the maxillæ, and probably of the ovary also—for neither Ehrenberg nor Weisse could satisfactorily make out the existence of the latter, —and, further, the presence, as the Berlin Professor points out, of two sorts of eggs upon *Notommata Brachionus*, the smaller of which bring forth individuals of the supposed different species, *Notommata granularis*.

The evidence for the male nature of *Diglena granularis* (Weisse) is its constant occurrence in company with *D. Catellina*, and the production of two sorts of eggs by the latter, the smaller of which give birth to embryos wanting the dental apparatus. Such imperfect beings as the *Diglena granularis* and the *Notommata granularis* were explained by Weisse to be immature or premature embryos. "It is truly interesting," says Leydig, "that Weisse, at the time he wrote perfectly ignorant of male Rotifera, should arrive at the conclusion that *Notommata granularis*, *Diglena granularis*, and *Enteroplea Hydatina* were not distinct species, but the incomplete and toothless young of the several species, *Notommata Brachionus*, *Diglena Catellina*, and *Hydatina senta*." It is added in a note—"Under the name *Notommata granularis* may well be associated together the very similar males as well of *Notommata Brachionus*, as also of *B. urceolaris* and *B. Pala.*" A few notes, in illustration may be added from Cohn's account of the male of *Brachionus urceolaris* (*Zeitschr.* 1855, p. 471). This is much smaller and more active than the females. Its rotary apparatus forms a wide ciliated rim; but its cilia are not turned inwards and downwards, as in the females, to enter the mouth, for no such orifice exists: hence there is no maxillary head, no intestine, and no gastric glands. In the place of those organs lies a large pyriform saccular testicle, as much as $\frac{1}{1200}$th of an inch in length, incompletely filled with fine dark corpuscles, which, when mature, acquire the characteristic figure and swarming movements of spermatozoa. The wall of the testicle is excessively thick, perhaps muscular, and is extended upwards into a thick cylindrical band, which appears to serve as a medium of attachment to fix the gland above to the region of the cephalic disk. At its posterior end, the testis presents a close longitudinal striation, and is perforated by an aperture which opens into a wide canal ending in the penis. This last-named organ has the aspect of a short tube, which, as a rule, lies free upon the foot, and extends nearly to its extremity. Its inner canal, and its external border, exhibit vibratile action. The foot is transversely wrinkled, and ends in two small toes. About the origin of the penis from the testicle are two club-shaped glands which pour their secretion into the canal; and near them is the contractile vesicle, giving off its respiratory canal on each side, with the usual tag-like appendages. Several spherical cell-looking bodies occur about the head, with the largest of which the eye-specks are in connexion, and which may therefore be considered the cerebral ganglion. Upon the testis, near its lower end, two or three vesicles are placed, filled with dark granules, resembling those seen in *Enteroplea Hydatina*, and of which we cannot predicate further than that they are not of the nature of urinary concretions (as Leydig imagined), but in some way belong to the sexual apparatus, or else are unconsumed cells of the yelk-mass.

The tubular or band-like prolongation from the upper extremity of the testicle, noticed by Cohn, and considered by him a "suspensor testis," represents, in Leydig's opinion, rather the rudiment of the undeveloped alimentary tube. This author likewise denies Cohn's statement that the walls of the testis are thick and muscular, asserting that they consist of a thin membrane.

The *spermatozoa, i. e.* the fecundating male particles, have been described by Mr. Dalrymple, Gosse, and Leydig. We borrow the description of the latter as the more recent:—"The testicle (XXXVII. 29 *c*) of *Notommata Sieboldii* is at once seen to be more or less completely filled with spermatozoa, arranged about the excretory duct in a radiating manner; when not too much compressed, they move about within the testis. On isolating by slight pressure the contents of the organ, may be noticed, 1, large round vesicles, in which, by a stronger magnifying power, two, or probably more, hyaline nuclei with nucleoli, entirely occupying the space, may be distinguished (XXXVII. 30 *e*); 2, somewhat larger cell-formed elements, disposed in a radiating manner about a centre, and larger towards one side (XXXVII. 30 *c*)—at the rounded extremity a clear nucleus, with a nuclear corpuscle, is always placed; 3, elongated, mostly falcate or curved structures, which have the before-mentioned nuclei in their interior, and on one margin are expanded into an evidently undulating membrane (XXXVII. 30 *a*, *b*, *d*). They move about, and swim hither and thither, in such a manner that they remind one not a little of many Infusoria, having a clear sharply-defined contour and a rod-like figure, with a slight enlargement at the middle. It is these bodies which lie around the commencement of the excretory duct, and give rise to the apparent striation above alluded to." In *Hydatina senta* the spermatozoa are likewise of two forms, and are noticed sometimes to have a swarming movement even within the testis.

Leydig has been unable to satisfy himself whether the stave- or rod-like variety (XXXVII. 30 *f*) is to be considered the ripest of the spermatozoa, and derived from one of the other forms, or whether there are two sorts of spermatozoa in *Notommata Sieboldii*, as there are in *Paludina vivipara*, one of the Mollusca.

Perty states briefly and generally, of the spermatozoa of Rotatoria, that they have a broad-oval refracting body, and a tail-like appendage.

The spermatozoa have been seen within the abdominal cavity of not a few female Rotifera, freely moving about within it. For instance, it has been witnessed in *Brachionus*, *Conochilus*, *Lacinularia*, *Megalotrocha*, and *Hydatina*. It is not known how they reach this cavity, since the cloaca into which they are normally received is a closed sac. Cohn imagines they may enter through some aperture in the integument as yet unnoticed; it is, however, more conceivable that they may pass from the cloaca into the respiratory tubes, and escape into the general cavity through the vibratile tags—supposing these last to terminate by open mouths. On the other hand, it is just possible that some supposed examples of the presence of spermatozoa within the abdominal cavity, have rather been instances of parasitic beings (Entozoa) in the interior. Thus, in *Hydatina senta*, Leydig describes the interior occupied by many numerous active animalcules, which he refers to the genus *Astasia*.

The minute male beings just considered are brought into existence for the sole purpose of fertilizing the ova of the larger and highly-organized female animals. In relation to the females, they may be looked upon as little other than parasites; they are even deficient in organs necessary to carry on their own existence: the one purpose of impregnating the opposite sex being fulfilled, their career is ended; and this career is so brief, that the complicated apparatus otherwise required to nourish and sustain the beings can be dispensed with.

The early history of the male Rotifer is that of the female. The evolution of the ovum from the ovary, and the changes transpiring in the contents of the egg until the several organs become distinguishable, are identical in the two. The following particulars from Cohn's paper (*Zeitschr.* 1855, p. 471) will serve for illustration. The males of *Brachionus urceolaris* are developed from smaller eggs than the females, and which are adherent in large number at the same time to the parent-animal. These eggs are very spherical, and reach $\frac{1}{600}$th of an inch in length and $\frac{1}{804}$th in diameter. Their shell is more delicate, the contents clearer and much more transparent, from containing fewer granules, and of a pale-yellow hue, whilst the usual summer eggs are dusky grey. Even when mature, this greater transparency and absence of colour persist. Fission proceeds in the same way as in the female ova; and after it has been many times repeated, the different organs of the embryo begin to make their appearance,—the red eye-specks being among the first. However, unlike what happens in the female ova, no signs of the maxillary apparatus come into view, but two or three dark heaps of granules which are not seen in those. When mature, the embryo springs from the shell through a transverse rupture, and is then seen to have a totally different figure from the female beings, and at least three times smaller. When completely extended, it measures only between $\frac{1}{324}$th and $\frac{1}{264}$th of an inch in length, and $\frac{1}{720}$th to $\frac{1}{850}$th in width, and is observed at the first glance to be destitute of the firm integument or shield of the female animals, and to have a short-cylindrical figure, prolonged anteriorly in the form of a short head separated by a constriction from the body. The foot is short and tubular, the head crowned by a flattened disk expanded into a wide margin, which is clothed with long vibratile cilia and a few non-vibratile bristles. Their movements are extraordinarily energetic.

The same female may lay in succession several male ova. According to Leydig, both male and female ova are not generated at the same time. The small size and relatively incomplete organization of the male Rotifera is a circumstance not peculiar to the class; the like is seen in the imperfect "imago" of many Insects, destined only to a sexual purpose, in the parasite-like males of *Lernæa*, in the miniature and incomplete males of *Daphniadæ*, and in the equally inferior male representatives of *Polynoë*, *Exogone*, and of the Nematoda generally, among Vermes. Leydig, moreover, finds an analogous fact in the Siphonophora, in which he assumes the so-called genital capsules, distributed everywhere in the aggregate mass of animals, to have a male character, and shows this opinion is in harmony with the views put forward by Leuckart respecting them.

Mr. Gosse's conclusion (*Phil. Trans.* 1857, p. 322) is, that "a distinction of sex is the normal condition of the class, or at least of that group which is most typical, viz. such as have articulated *mallei* working upon a separate articulated *incus*. Whether the same rule prevails so generally in those which have the mallei and incus fused together into quadrantic masses, and in those in which the organs exist in a rudimentary condition, is a question yet to be determined. As these are certainly the lowest forms of their class, it is possible that hermaphroditism may be found in them—in the *Philodinadæ*, for instance."

The summary of the facts as yet ascertained, concerning male Rotatoria, will form a valuable addendum to our account:—

"The most prominent thing that strikes us is the absolute and universal atrophy (so to speak) of the digestive system in male Rotifera. Another curious peculiarity is the dissimilarity that always exists between the sexes. In *Asplanchna* and *Hydatina* the resemblance is at its highest point; in every other instance observed, the sexes are so unlike, that they would be taken for widely-remote genera. The male is always inferior in size, and also in organization, to the female.

"Whether certain individuals produce only male, and others only female young, or whether separate impregnations are required for the production of the separate sexes, I do not know; but from all my observations I gather that the development of the one sex never takes place coetaneously with that of the other; for male and female eggs are never seen attached to the same parent, and the immature eggs in the ovary invariably develope themselves into the same sex as those which are already extruded.

"The duration of life in the male is always very brief. I have never been able to preserve one alive for twenty-four hours. Their one business is to impregnate the females, which is the work of a few minutes, probably, in a state of freedom; and for this momentary occupation no supply of loss, by assimilation of food, is wanted; and hence we can understand the lack of the nutritive organism.

"*Some* organs are found, with greater or less distinctness, in all. The (presumed) male of *Hydatina senta* received its names of *Enteroplea* and *Organ-fisch* from Ehrenberg on account of the copiousness of its internal organization. A muscular system is well developed there, and in the males of *Asplanchna* and of *Brachionus Mülleri*; and, from the varied movements of all, its existence may be inferred where it is not detected. The frontal cilia are, in almost all cases, much more developed than in the females; the result of which endowment is seen in the excessive rapidity with which the male shoots in all directions through the water. The great head-mass of granular substance is generally distinct; and in several cases (as in the *Asplanchnæ* and in *Brachionus Dorcas* and *Br. Mülleri*) the great occipital ganglion is well-defined, with the red eye seated on it as in the other sex. Even where the ganglion is not apparent, the eye is conspicuous, with the exception of *Sacculus* and *Polyarthra*; and in this last instance the small size of the animal must be borne in mind, and the density of the anterior parts.

"In the (presumed) male of *Hydatina*, in those of all the *Asplanchnæ*, and of *Brachionus Dorcas*, there are organs answering to the lateral convoluted threads of the female; and, in *Asplanchna Brightwellii* at least, these are accompanied by tremulous tags, and by a contractile bladder.

"A large mass of substance which, being perfectly opaque, appears black by transmitted light, but is white when the rays are reflected, is so generally found in male Rotifera as to be characteristic, though it is not universally present. I do not find it in the *Asplanchnæ*, nor in *Sacculus*. On the other hand, I have observed it in the young of *Stephanoceros*, *Floscularia complanata*, and *F. cornuta*; and Ehrenberg mentions it in *F. ornata* and *Lacinularia*. In *Stephanoceros*, it was certainly associated with well-developed jaws; and hence I presume it is not exclusively an indication of the male sex. The mass is sometimes broken up into fragments, of irregular size and shape, and sometimes apparently pulverulent. In general, it appears to lie loosely in the midst of the granular amorphous matter that occupies the posterior region of the body-cavity; but in *Brachionus Pala*, and especially in *Br. amphiceros*, I have fancied that I discerned traces of a vesicle, within which the white substance seems to be contained.

"On the nature of this substance I have no light from personal research. Dr. Leydig, however, considers it to be a urinary concretion (*Harnconcremente*), analogous to the chalky fluid which is discharged by many insects immediately after their evolution from pupæ.

"In the male of *Asplanchna Brightwellii*, there is, as its discoverer observes, 'a conspicuous round sperm-vessel, or testis, in which. . . . spermatozoa in active vibratile motion may be seen.' Mr. Dalrymple, and subsequently myself, also saw these, both within the sac and discharged by pressure. Each spermatozoon, according to my own observation, consists of an oblong body, $\frac{1}{1750}$th of an inch long, and an abrupt, slender, vibratile tail of equal length. In the sperm-sac of *A. Sieboldii*, Dr. Leydig finds various seminal elements, viz. round cells; pyriform cells, drawn out to a fine point, and adhering to each other by their rounded ends in a stellate manner; oblong bodies, with one side dilated into a free, undulating, membranous border; and slender, stiff, rod-like bodies, with a central swelling; all containing nucleated nuclei. On the male of *A. priodonta*, my observations were too limited to determine more than the existence of the globular sperm-sac.

"In *Brachionus rubens* and *Br. Mülleri* I found spermatozoa, which I have above described. In the latter, the sperm-bag is of great size, and contains, besides the spermatozoa of unusual development, slender spiculiform bodies, which may be the equivalents of the little rods described by Dr. Leydig in *Aspl. Sieboldii*. The sperm-bag (in *Br. Mülleri*) is closed posteriorly, as it is also in *Asp. Brightwellii*, by what appears to be a true sphincter; and such I conjecture to be the explanation of those diverging lines which M. Dujardin saw in *Enteroplea* (so-called), which he considered to be pedicles of his '*touffes de granules*,' while the '*touffes*' themselves I take to have been the masses of urinary concrement. Dr. Leydig, however, considers the whole to have been masses of spermatozoids.

"The outlet of the sperm-bag is, in all cases, by a thick protrusile and retractile penis. Wherever a foot exists, this intromittent organ is continuously united to its dorsal side, and is often so greatly developed that the foot itself appears as an appendage. The protrusion of the organ, at least in most of the examples that I have noticed, is by the eversion of the integuments. When these are evolved to the utmost, the organ is seen to be a thick column, conical or nearly cylindrical, with the extremity truncate, and surrounded by a wreath of vibratile cilia. It was doubtless the extremity of the penis that M. Dujardin saw as '*un organe cilié entre les muscles de la queue*,' in the (so-called) *Enteroplea*. The male of *Sacculus viridis*, a species which is footless in both the sexes, is the only example in which I have not seen the penis; but the organ is probably wholly retractile within the body, and my observations, on the only individual of this sex that I saw, were insufficient to determine anything concerning it."

That male Rotatoria have been recognized in comparatively few species, admits of several explanations. The smaller size and comparative rarity of the males; their dissimilarity of figure to that of the females, which, coupled with imperfect examinations or misconception of their interior organization, would readily lead to their institution as new species or genera; the influence of the prevalent hypothesis of a hermaphrodite nature, and the consequent exclusive search for male organs in the perfect female forms, in which, too, the uncertainty appertaining to the purpose of several appreciable tissues or organs would tend still further to lead astray; the short existence of the males, and even that brief life limited, it would seem, to a particular period of the year, the early spring, when such creatures are less sought after; each and all these are circumstances which have caused the male Rotatoria to be overlooked, and continue to do so. However, the non-recognition of the male animals occurs not only in the case of the Rotatoria, but also of other classes of animals, even more highly organized and so large as to be capable of examination without the aid of the microscope. Among minuter organisms in which an uncertainty prevails, may be mentioned the *Daphniadæ* and other Entomostraca, among the majority of genera of which the males are still undetected, nevertheless the bisexual character of the class is admitted.

The comparative rarity of male Rotatoria admits of an interpretation derived from analogy. It is a well-recognized fact, that in several classes of Invertebrata (for example, in *Daphniadæ* and, among Insecta, in the genus *Aphis*) several generations succeed one another without the concurrence of a male animal in their production,—a phenomenon well named by Prof. Owen, Parthenogenesis or Virgin-generation. Now it clearly appears that one contact with a male Rotifer may suffice for the fertilization of all the germinal cells in any female ovary, and be followed by their successive development. To use the language of Prof. Owen, the *spermatic force* once applied suffices for the impregnation of a multitude of ova, or, in fact, of the whole ovary; and the fact quoted, of *Aphides* developed by the immediate action of the spermatic force being in their turns capable of reproducing others by gemmation without a renewal of that force, warrants the supposition that an analogous phenomenon may exist in the Rotatoria. This analogy is strengthened by Mr. Huxley's interpretation of the nature and purpose of "winter" ova, which he believes to be the instruments of an *asexual* reproduction. A portion of the ovary seems to be modified and extruded, and subsequently to generate a couple of embryos. On the other hand, in the *Aphides* an internal germinal mass remains within the body, and a portion of it appears to be abstracted by each successive individual produced, until at length the spermatic force is exhausted. This internal germinal or reproductive body, the instrument of an *asexual* generation in the *Aphides*, is then surely homologous with the extruded external generative bodies, or "ephippial ova," of Rotatoria. Such an asexual reproduction implies a fewness of male beings compared with the multitude of young which must be developed by the generative processes. Again, the male Rotatoria are not only developed in smaller numbers than the female, but their whole term of existence is very brief, only long enough to fulfil their generative purpose; and, lastly, they are to be found only at particular seasons, mostly in the spring.

Another obvious reason for the scarcity of male Rotifera suggests itself, viz. that the social institutions of the class may not be on the monogamous model, but that one little active male may divide his favours among a whole harem of females before he completes his brief career. However this may be, to discover the male of any one species, continuous observation is needed, particularly at certain times of the year; and it must be confessed that but few Rotatoria have hitherto had their history fully investigated. In most cases, the examination of a species has been casually undertaken; the attention has been directed to it only by some accidental circumstances, and this only on some one occasion. We cannot, therefore, wonder that the rarely-occurring males have not often been encountered. But the most satisfactory means of determining the existence and characters of the males of any species of Rotatoria have latterly been furnished by the careful descriptions of the special characteristics of male ova, whereby they can be distinguished even before leaving the oviduct, and their developmental history traced forwards until their maturity.

We may mention that Mr. Hallett, formerly demonstrator of anatomy in the University of Edinburgh, and subsequently a student in anatomy at the College of Surgeons, London, directed his special attention for many years to the Rotatoria, and especially to the detection of the male individuals; and although his early death has deprived naturalists of the published results of his researches, yet, from repeated verbal communication, we can state that he had arrived at the discovery of the male beings of the majority of the Rotatoria.

Doubtful Male Organs.—Many naturalists are unprepared to admit bisexuality to be the universal rule in Rotatoria; and several eminent observers are disposed to consider certain organs in female animals to be of a male sexual character.

Prof. Williamson, in his history of *Melicerta*, says—"I have sought in vain for any organ to which the functions of a spermatic gland can be indisputably assigned. Immediately beneath the lower stomach and the contiguous oviduct, there is an elongated pyramidal organ, apparently hollow, the thick extremity of which is directed towards the ovary, and its opposite attenuated portion passes upwards towards the cloaca, between the oviduct and the general integument. Into the thick inferior extremity of this organ, there are inserted, exactly opposite to each other, two long-cylindrical appendages, which diverge, and, passing on each side of the alimentary canal, proceed towards the upper part of the body, where their extremities are not easily traced. In but one instance I observed them to terminate in a series of irregular convolutions near the base of the two tentacles. Though not yet capable of demonstration, it appears probable that this curious appendage may be a filamentous spermatic tube resembling those found in many Articulata. That they are tubes, and not muscular bands, appears unquestionable; and as they have obviously a direct connexion with the cloaca, they might easily discharge a fertilizing secretion into that common excretory canal, from which it would find its way to the ovary through the oviduct" (p. 432).

Now it is to be remarked that Mr. Williamson states he could discover "no special organs of circulation or respiration, no vessels or pulsating organs," and that the two tubes he has referred to as being possibly spermatic ducts are the homologues of similar ones in other Rotifera, to which Ehrenberg has assigned fertilizing functions. Further on he observes—"The singular bodies resembling spermatozoa exist in various parts of the organism, where they are apparently enclosed within hollow canals. I have never seen them occupying the two main trunks of the 'water-vascular system' or cæca; nor can I succeed in tracing any connexion between them. In several cases I have seen one or two of these curious bodies opposite the centre of the upper stomach, very near to, but independent of, the main cæcal canal, and at some distance below the point where the latter probably subdivides into branches. Near the neck there are usually from two to three pairs. Their vibratile motion ceases the moment the animal is killed by pressure. This fact does not countenance the idea that they are spermatozoa."

From the above remarks and statements, it seems to us quite clear that the pyramidal sac opening into the cloaca, and its upwardly-prolonged canals referred to, are nothing more than the "water-vascular system" of the *Melicerta*, and that more or fewer of the observed vibratile bodies are, in fact, the ciliated tremulous tags. Had the pyramidal sac represented a testicle, spermatozoa ought to have been seen within it; for these particles are readily cognizable by their size, figure, and movements.

Prof. Huxley having failed to find a male among some scores of female *Lacinulariæ*, or a single ordinary spermatozoon, is disposed to recognize the male sexual element in some singular bodies met with in many individuals he examined. These bodies "answered precisely to Kölliker's description of the spermatozoa" of *Megalotrocha*. They had a pyramidal head about $\frac{1}{1000}$th of an inch in diameter, by which they were attached to the parietes of the body, and an appendage four times as long, which underwent the most extraordinary contortions,—resembling, however, a vibrating membrane much more than the tail of a spermatozoon, as the undulating motion appeared to take place on only one side of the appendage, which was zigzagged, while the other remained smooth. "According to Kölliker, again, these bodies are found only in those animals which possess ova undergoing the process of yelk-division, while I found them as frequently in those young forms which had not yet developed ova, but only possessed an ovary.

"Are these bodies spermatozoa? Against this view we have the unquestionable separation of the sexes in *Notommata*, and the very great difference between them and the spermatozoa of *Notommata*. Neither the mode of development, nor the changes undergone by the ovum, afford any certain test that it requires or has suffered fecundation, inasmuch as the process closely resembles the original development of the *Aphides*.

"In the view that Kölliker's bodies are true spermatozoa, it might be said, 1. That the sexes are united in most *Distomata*, for instance, and separated in species closely allied (e. g. *D. Okenii*). 2. That the differences between these bodies and the spermatozoa of *Notommata*, is not greater than the difference between those of Tritons and those of *Rana*. 3. That their development from nucleated cells within the body of *Megalotrocha* (according to Kölliker) is strong evidence as to their having *some* function to perform; and it is difficult to imagine what that can be if it be not that of spermatozoa. However, it seems to me impossible to come to any definite conclusion upon the subject at present."

In *Melicerta*, Prof. Huxley notes having met with "an oval sac lying below the ovary, and containing a number of strongly-refracting particles, closely resembling in size and form the heads of the spermatozoa of *Lacinularia*."

These views of Mr. Huxley are of no value in deciding the question; they rest on a supposed similarity between the bodies discovered and those which Kölliker believed to be spermatozoa in *Megalatrocha*,—an opinion not incontrovertible. On the other hand, their spermatozoid nature is discountenanced by their similarity (which, indeed, Huxley remarks) to undoubted spermatozoa of Rotifera.

In a new species of *Melicerta* discovered by Prof. Bailey in America, that accurate observer found that pressure between two plates of glass liberated vast numbers of spermatozoa; but he was unable to ascertain from what organ in the animal they were set free. The observation, however, is important as indicating the existence of true male organs in *Melicerta* of a very different character from those suggested by various observers as having possibly fecundating functions.

Respecting these questionable male elements, Leydig has the following remarks, premising that the detection of spermatic particles in one species furnishes a criterion in pronouncing upon the signification of some other bodies:—"I have heretofore mentioned my idea that the hairy corpuscles of *Lacinularia* (occupying the general cavity of the body, and impelled hither and thither by its movements) are seminal particles: although this is still questionable, yet these presumed parasites of *Lacinularia* must, I believe, be still rather looked upon as unequivocal spermatozoids. The form and structure, moreover, of the bodies figured by Huxley, and doubtfully called by him spermatozoa, have an evident affinity with the seminal elements of *Notommata Sieboldii*. It also seems to me probable that the spermatozoids portrayed by Kölliker in *Megalotrocha* are really such, and that the animals in which they are found should be esteemed as previously impregnated females. I moreover consider that the illustrations furnished by Ehrenberg of *Conochilus volvox*, show an individual with two spermatozoa; and the account referring to it, in which he says 'I lately saw oscillating, very peculiar, gill-like organs, in the form of two spirally-twisted bands, at the posterior extremity of the body,' also speaks in favour of this signification. The entire delineation of these 'spiral gills' might replace very well that of the peculiar seminal elements with undulating membranes."

Afterwards, when speaking of the parasites of Rotatoria, Leydig observes that having formerly erroneously described the seminal corpuscles of *Lacinularia* as parasites, he must now, on the other hand, class the once-presumed spermatic particles with parasitic organisms.

In the course of subsequent researches on *Hydatina senta* (Müller's *Archiv*, 1857, p. 104), Leydig has discovered the same sort of structures in that animal. He writes—"They are globular bodies with sharp outlines; and their margin looks as if clothed with fine hairs. Towards the end of March, the entire abdominal cavity was in many specimens so filled with them that the animals presented a white appearance by reflected light; yet the animals so affected swarm about just as briskly as the others." This repletion with such particles appears to us to intimate that they cannot be spermatozoa, either generated within the beings themselves or received from without from male animals. Indeed their occurrence within the abdomen of *Hydatina senta* is of itself an argument against their being spermatozoa derived from a male gland within, inasmuch as this species is proved to be impregnated by its own male partner, formerly known as the *Enteroplea Hydatina*. The question presents itself, whether they can be derivable from the food, as products of digestion or chyle-globules.

The search for male Rotatoria has led the occasional connexion of two individuals to be noticed, and to be explained as of a sexual character. Perty noticed two individuals of *Colurus uncinatus*, and two of *Lepadella ovalis*, in union. But such connexions may rather be considered accidental; for Perty remarked a *Colurus* so attached to *Lepadella*, and a *Chætonotus Larus* to *Lepadella ovalis*. Cohn has had his attention directed to the same circumstance, and remarks that two Rotatoria of the same or even of a different species are very often to be seen attached together, sometimes by the back, at others by the abdomen, at others by the pseudopodium, and to swim about together for a length of time. This he has seen in *Diglena*, *Colurus*, and *Lepadella*; it has, however, no connexion with the reproductive function.

Of the Duration and Conditions of Life of the Rotatoria, and of their Habitats and Distribution.—It is next to impossible to determine, by direct observation, the duration of life among the Rotatoria when placed under natural and favourable conditions. Many may well be supposed to survive from their birth in the spring until the winter, and not a few even through this season until some future period, since observations prove their power of assuming a torpid condition when existing circumstances are unfavourable to the full exercise of life. It has been noticed by Ehrenberg, of some Rotatoria living, so to speak, in confinement, or in a limited quantity of water under examination, that when the weather was warm and nourishment abundant, life was prolonged to 18 or 20 days and more; and Mr. Gosse also speaks of a *Melicerta* which lived in confinement for 14 days.

The conditions of life, or the causes affecting the vitality of Rotifera favourably or unfavourably, are in some respects very remarkable, as an appeal to their habitats alone would abundantly illustrate.

It is during the height of summer that the Rotifera are multiplied most abundantly; but when the cold frosty nights of autumn supervene, their numbers undergo a rapid reduction. However, often during the most beautiful parts of the year, as Perty remarks, a sudden decrease will occur.

"Two kinds of disease," writes Ehrenberg, "destroy the *Hydatina* and most of the Rotatoria: 1, the formation of vesicles, which give rise to the appearance of small rings all over the creature; and, 2, the formation of granules which so penetrate the internal organs that these seem composed of them, and have a shagreen appearance." The first condition has been noted by Weisse, who regards the apparent vesicles as parasitic organisms.

The Rotatoria also suffer from the overgrowth upon their surface of Algæ and of parasitic animals, Protozoa and the like, and are at length destroyed thereby. Foul or decomposing water is incompatible with their existence, as are some chemical mixtures, whilst to others they seem indifferent. Thus *Hydatinæ* have been fed with rhubarb and indigo in powder without sensible effect, and neither calomel nor corrosive sublimate kills them; at least, they live for some time after these substances have been mixed with the water. Strychnia causes instant death.

The deprival or the want of renewal of air in water inhabited by Rotifera causes their destruction, for example, when collected in a bottle for examination, the cork being allowed to remain too long. In like manner the exclusion of air by a pellicle of oil on the surface of the water, or the withdrawal of air by means of an air pump, speedily destroys the Rotatorial inhabitants. Ehrenberg affirms that they exist much longer in an atmosphere of nitrogen than in one of carbonic acid or of hydrogen, and that the vapour of sulphur speedily puts an end to their existence.

Still a very imperfect renewal of air seems, at least in some instances, to suffice—as in the case of the *Rotifer vulgaris* and *R. parasita*, which have been seen within the spheres of *Volvox* and in the cells of aquatic plants (the *Vaucheria clavata*.) Perty likewise mentions the *Notommata Werneckii* as inhabiting the *Vaucheria cæspitosa*; and *Albertia vermicularis* is parasitic within the intestine of earth-worms and slugs. In all these instances life is compatible with a very slight renewal of atmospheric air, or, in fact, is supported amid the gases generated within these organic beings and mixed with their fluids.

The evaporation of the water from around Rotifera, as when under examination by the microscope, is a frequent cause of their destruction, by the breaking up of their soft parts. But there is a happy provision against such evil consequences; for, so soon as the animal experiences the deficiency of water around it, it withdraws its tender wheel apparatus, and limits its exposed parts as much as possible, by retracting its pseudopodium and contracting itself into a ball-like form, so that only the denser integument is exposed to the injurious influences, and the evaporation of water from the contained organs reduced to its minimum.

Indeed the Rotatoria, in part at least, have a remarkable power of preserving their vitality, not only when left dry by ordinary evaporation, but also when thoroughly desiccated by the assistance of heat. Leuwenhoek and Spallanzani experimented on them, and announced the fact of their revivification on the addition of moisture, months and even years after their complete desiccation. Schrank, Bory St. Vincent, and Ehrenberg questioned the truth of this statement, at least in its full acceptation; and the writer last-named affirmed "that wherever these creatures are completely desiccated, life can never again be restored. In this respect the Rotifera exactly correspond with animals of a larger kind: like them, for a time they may continue in a lethargic and motionless condition; but, as is well known, there will be going on within them a consumption or wasting away of the body, equivalent to so much nourishment from without as would be needed for the sustentation of life." Neither the last statement nor those preceding it are correct; MM. Schultze and Doyère have repeated and confirmed the experiments of the old observers; and the latter authority concludes that Rotifera may be completely dried in pure sand in the open air, and in a vacuum, without losing the capability of being revived by moisture. Many indeed are sacrificed in the process; but enough recover to demonstrate the possibility of the fact.

This extraordinary power of resuscitation after drying explains the re-appearance of Rotatoria on the collection of water in shallow pools which have been entirely dried up by the hot sun of summer, and their constant presence in the dry debris of the roofs, and even of the interiors of houses.

In their relation to temperature, also, the Rotatoria exhibit great tolerance. M. Doyère proved that when placed in water at from 113° to 118°, they could afterwards be revived, but that when thrown suddenly into boiling water (at 212°) they were at once killed. In the latter case, the sudden heating is supposed to coagulate the albuminoid contents of the animals, and in that way to cause death, because individuals previously dried by a gradually raised heat of 216°, 252°, and even of 261°, were many of them still capable of being revived.

On the other hand, Rotatoria can live in water at the freezing-point. They are to be found under ice, and also within the hollow cavities of ice; and Perty mentions a score of species which he met with in such localities. He also recounts meeting with individuals contracted in a more or less globular figure, preparatory, as he surmises, to a winter sleep or torpor. He figures a *Philodina erythrophthalma* (XXXVIII. 4) in this condition, which is precisely the same as that assumed when the animal is left dry; and he adds that when *Scaridium longicaudum* assumes this state, it withdraws its head within its envelope and doubles its tail under the abdomen, just in the same way as a *Podura.* Ehrenberg doubtless refers to this same contracted condition in the account before quoted from him (p. 449-50) respecting the Rotifera found at great altitudes among snow, which he described as having an ovate figure and enclosed in an egg-shaped envelope.

Conochilus and *Lacinularia* are examples of Rotifera living in aggregated masses. The former recalls, by its compound revolving spheres, the appearance of *Volvox Globator,* whilst the latter occurs in small transparent jelly-like balls adherent to the leaves of aquatic plants.

At times the Rotatoria multiply so rapidly in small stagnant pools as to colour the water. *Hydatina senta, Diglena catellina, Triarthra,* and *Lepadella* are adduced by Ehrenberg as producing a milky turbidity in water, and the *Typhlina viridis* as imparting a green colour.

The *Synchæta Baltica* has been presumed to be phosphorescent; and *Anuræa biremis* was discovered in phosphorescent sea-water.

The Rotatoria are distributed everywhere over the surface of the earth, inhabiting its waters, both fresh and salt. Of the known species, by far the greater number are dwellers in fresh water, abounding in pools, ditches, and gently-flowing streams, especially where aquatic plants grow in sufficient quantity to afford shelter and indirectly supply food by the hosts of animalcules which congregate on and about them. A too much overgrown or shaded piece of water is less favourable; for they require a complete intermixture of air with the water, and the vivifying influence of the sun, for their healthy existence. Some species especially delight in the little turfy pools on moors or in boggy ground; others have been especially found in green-coloured ponds—the colour being due to Protozoa and minute Algæ, which furnish them with suitable food.

Some of the early observers sought these animalcules especially in infusions, very generally made with sage-leaves and chopped hay; but the Rotifera are comparatively rare in infusions: a few common species only appear; and unless the infusion be comparatively fresh, none will be found; for they occur in no fluid in which decomposition is going forward. When they do exist in these infusions, they appear at a later period than do the Monadina and less highly organized infusorial forms.

The known salt-water species are comparatively few; this is very possibly owing to their being much less sought after than the freshwater animals. The principal marine forms recognized are *Brachionus Mülleri*, *B. heptatomus*, and *Synchæta Baltica*. *Distemma marina* and *Furcularia marina*, *Colurus uncinatus*, *C. caudatus*, and *Anuræa striata* are encountered in both fresh and salt water: several are found in brackish water.

Immersion in water is, however, not necessary to their existence: thus they are to be found in the damp earthy deposit from rain-water spouts, and in the detritus of the walls and roofs of houses; in the moist humus or decaying vegetable matter about trees, and especially upon the moist roots and leaves of mosses and lichens—for example, among the tufts of *Bryum* and of *Hypnum*, from which they may be separated by washing with a little water.

We have mentioned the peculiar habitat of *Albertia*, within the intestine of the earth-worm, of which animal it may be accounted an entozoon; the *Notommata Parasitus* also leads a parasitic existence within the hollow spheres of *Volvox Globator*; and M. Morren, many years since, gave the following interesting history of the habitat of *Rotifer vulgaris* in the cells of *Vaucheria clavata* (*A. N. H.* vi. p. 344):—

"The labours of Rœper show that the cells of *Sphagnum* are sometimes furnished with openings, which place their interior cavity in communication with the air or water in which they are immersed. This skilful observer satisfied himself that, when circumstances are favourable, the *Rotifer vulgaris*, one of the Infusoria whose organization has been explained by the researches of Ehrenberg, exists in the cells of the *Sphagnum obtusifolium*. This grew in the air, in the middle of a turf-pit: but Rœper observed its leaves in water; he does not mention whether the infusorial animal came from thence, or whether it was previously contained in the cavities of the cells. The general purport of the paper seems to imply that these Rotifers exist in the cells of that part of the plant which was exposed to the air; and in this case, the presence of an animal so complicated, living as a parasite in the cells of a utricular aërial tissue, is a phænomenon of the most curious kind in the physiology of plants, and the more so as this animal is an aquatic one.

"I recollected that, the last year of my residence in Flanders, I found at

Everghem, near Ghent, the *Vaucheria clavata*, in which I observed something similar. M. Unger had already published the following details respecting this plant in 1828: 'Beneath the emptied tubercles and at several points of the principal stalk, at different angles, rather narrower branches are produced; these branches are generally very long, and greatly exceed the principal stalk in length. At the end of ten or twelve days after their development, there are seen, towards one or other of their extremities, here and there, at different distances from the summit, protuberances of a clavate form, more or less regular, straight or slightly bent back; and others on the sides of the stalk, which have the form of a capsule or vesicle. These vesicles are at first of a uniform bright-green colour; and without increase of size, which exceeds several times that of the branches, they always become of a blackish-green colour, darker towards the base; and then one or two globules of a reddish-brown may be clearly distinguished there, often surrounded by smaller granules, evidently destitute of motion, whilst the great ones move spontaneously and slowly here and there in the interior of the capsule, by unequal contractions and dilatations, whence arise remarkable changes of form. I saw these globules, at the end of eight or ten days after their appearance, still enclosed in the capsule, moving more and more slowly, receiving no very decided increase, whilst the base of the capsule became more transparent; at last I observed that, instead of their expulsion, which I was watching for, the extremity of the capsule at the end of some days took an angular form, and subsequently gave birth to two expansions in the form of horns; it remained in this state and became more and more pale, whilst the animalcule became darker and died; and afterwards it ended by perishing at the same time as the other parts of the Conferva.'

"Subsequent researches have not succeeded in informing us what this animal might be, of which Unger spoke. As this author drew so much attention to the spontaneous movements of the propagula of the *Vaucheriæ*, and as he admitted the passage from vegetable life—characterized, according to him, by immobility—to animal life, the principal criterion of which was motion, his animalcule was confounded with the propagula; and no one, so far as I know, has returned to this very interesting subject.

"When, therefore, I found the *Vaucheria clavata* at Everghem, I was as much surprised as pleased to see the mobile body noticed by Unger better than he did. With the aid of a higher magnifying power, I found it easy to ascertain the true nature of the animal; for it was not a propagulum, but a real animal, the *Rotifer vulgaris*, with its cilia imitating the wheel, its tail, &c.

"The first protuberances or vesicles which I saw containing this animal enclosed but one of them; afterwards they laid eggs and multiplied; but it seems that then they descend the tubes of the *Vaucheria* and lodge themselves in new protuberances, whose development they may possibly stimulate, as the galls and oak-apples, or organic transformations attributable to the influence of parasitic beings.

"The *Rotifer vulgaris* travels quite at his ease in these protuberances; he traverses the partitions, displaces the chromule and pushes it to the two extremities of the vesicle, so that this appears darker at these parts. One day I opened a protuberance gently: I waited to see the *Rotifer* spring out and enjoy the liberty so dear to all creatures, even to infusorial animals; but no—he preferred to bury himself in his prison, descending into the tubes of the plant, and to nestle himself in the middle of a mass of green matter, rather than swim about freely in the neighbourhood of his dwelling.

"Some of these protuberances had greenish threads appended to their free end, and others had none: I thought at first that these threads were some *mucus* from within, escaped through some opening which might have served the Rotifer as an entrance; but an attentive and lengthened observation convinced me that in this there was no solution of continuity, and that the arrival of the *Rotifers* in the *Vaucheriæ* was not at all to be explained in this way. How are these parasitic animalcules generated within them? This is what further research has some day to show. Meanwhile I have thought that it should be made known that the animalcule found in the *Vaucheriæ* by Unger was the *Rotifer vulgaris* of zoologists."

Several of the *Philodinæa*, and particularly the *Callidinæ*, have been met with in snow, along with the so-called red snow, in very cold regions, and at considerable elevations, such as above the perpetual snow-line of the Alps. Perty informs us that mosses and lichens collected in the Swiss mountains, at a height of 9000 feet, have yielded, on washing with distilled water, numerous Infusoria, including several Rotatoria, viz. *Callidina elegans, Rotifer vulgaris, Philodina roseola, Diglena catellina*, and *Ratulus lunaris.*

We have no data whereon to construct laws of geographical distribution for the Rotatoria. Observation has proved no definite regional limitation of species; wherever searched for, the same species seem discoverable.

Owing to the perishable nature of their tissues, the Rotifera do not occur in a fossil state; they are, moreover, rare components of the showers of Infusorial dust.

Of the Affinities and Classification of the Rotatoria.—That the Rotatoria, by their high degree of organization, should be elevated in the animal scale far above Protozoa, is now universally admitted. Indeed they cannot be rightly comprehended among Infusoria if this term be accepted to indicate a definite class of beings; for although there are slight general resemblances between some Rotatoria and Protozoa, no true near affinities of structure exist between them.

While naturalists generally are in accord on this necessary separation of Rotatoria from Protozoa, they are much at variance respecting the relative position of the Rotatoria in a classification of the Invertebrata, or, in other words, concerning the true affinities of the class. Thus Burmeister, Owen, Leydig, Dana, and Gosse would range them among Crustacea as a particular order; whilst Wiegmann, Milne-Edwards, Wagner, Siebold, Cohn, Perty, Williamson, Huxley, and others would class them with Vermes—a section comprehending Helminthæ, Turbellaria, and Annelida.

We shall first state the arguments used to demonstrate the Crustacean alliance, which are most fully and powerfully brought forward by Leydig; they are, that

"The external figure is rather that of Crustacea than that of Vermes. None of the latter have a jointed organ of motion, such as most Rotifera possess in their annulated or jointed pseudopodium devoid of all viscera.

"The shield-like hardened integument or lorica of some species, such as *Euchlanis* and *Salpina*, has its analogue among the Crustacea, whilst in none of the Vermes is a similar indurated cuticle to be found.

"Vermes are destitute of striated muscles; but Rotifera, equally with Crustacea, possess them. The movements of many species recall in a striking manner those of Crustaceans. The nervous system supplies further evidence; for although the Rotatoria have no pharyngeal ganglionic ring and no chain of abdominal ganglia proceeding from it, yet a similar deficiency prevails with the *Lophyropoda* and the *Daphniæ*, recognized Crustaceans, which have only a cerebral ganglion and radiating nerves like the Rotifera; consequently it cannot be adduced as a law, that the highly developed nervous system of the higher forms is an essential character of the Crustacea.

"The mode of termination of the sensitive nerves is that seen in Crustacea and Insecta; but the like is not known among Vermes. Ehrenberg pointed out the similarity of the eye-specks to those of Crustacea. The several segments and texture of the alimentary canal afford no decisive evidence, since many Vermes have horny jaws, as have the Rotifera. The masticatory apparatus of the young *Daphniæ* presents a pretty close resemblance with that of Rotatoria—the two opposed jaws expanding into a plate toothed with numerous transverse ridges, like those of *Lacinularia*. The stomach-glands probably have their analogues in the lobed glandular appendages—the so-called 'salivary glands' of Cirripedia.

"Similar organs, however, exist in many dorsibranchiate Vermes; and likewise in many Vermes and lower Crustacea the liver is represented by large cells with peculiar contents, situated in the walls of the stomach and intestine. The absence of an intestine in a few Rotifera may appear opposed to their Arthropodous type; yet in the Neuropterous larva of *Myrmeleo* the fæces are discharged by the mouth, and the rectum itself is transformed into a spinning organ. Moreover, the intestinal canal of many Rotifera, *e. g. Euchlanis* and *Stephanoceros*, recalls, in its peculiar bell-like movement, the exactly similar character of the intestine of certain parasitic Crustacea (*Achtheres*, *Tracheliastes*, &c.).

"The substance regarded as urinary concretions is evidently closely related to that formed in the larva of *Cyclops*; but no such point of resemblance is found among Vermes.

"Lastly, the anatomical and physiological phenomena of sexual life greatly favour the Crustacean relationship. Several minor particulars may be alluded to—such as the production of two kinds of ova (indeed the winter ova of *Triarthra* have a great likeness in the construction of the shell with the ephippial ova of *Daphnia*), the fact that many species carry their eggs about with them (although it is true the same is seen among Vermes, for instance *Clepsine*), and the occurrence of coloured oil-corpuscles in the yolk of not a few Rotatoria—all indicating a Crustacean type. The striking analogy between the male (in some sense aborted) Rotatoria and the males of many Crustacea is one of far higher import. It is only necessary to call to mind the diminutive parasitic males Nordmann discovered in the females of *Achtheres*, *Brachiella*, *Chondracanthus*, and *Anchorella*, and such as Kröyer found in other *Lernæopoda* and *Lernææ*.

"Moreover, the embryonic history of Rotifera is in favour of the alliance,—viz. the imperfect development of the young of several species, on their emergence from the egg, and the necessary metamorphosis they undergo before attaining the adult condition. Lastly, the diminution or even complete disappearance of the eyes after birth further indicates an analogy with certain Crustacean forms.

"Whilst the foregoing considerations approximate the Rotifers to the Crustacea, the nature of the respiratory apparatus and the presence of the vibratile cilia separate the two, and assimilate the Rotatoria to Vermes; yet in both these particulars they make an equal approach to Echinodermata, inasmuch as the peculiar vibratile organs of *Synapta digitata* appear to be similar structures with the vibrating organs (tags or gills)."

Now, argues Leydig, it seems but just to allow the sum of the resemblances to any class, if greater than that of the differences, to determine the systematic position. If this be granted, as the sum of resemblances of the Rotifera with the Crustaceans seems assuredly greater than that of their differences from them, their alliance with them must be admitted. Making due allowance, therefore, for the vibratile cilia and the peculiar respiratory apparatus of Rotatoria, Leydig would constitute them a special class of Crustacea, under the name of Ciliated Crustacea.

The foregoing arguments of Leydig for the Crustacean nature of Rotatoria have been severally met and replied to by C. Vogt, in a recent paper "On the Systematic Position of the Rotifera" (*Zeitschr.* 1855, p. 193). The objections advanced are these:—

That Leydig assigns an undue importance to external resemblances; and that, as to movements, there is as much similarity between those of *Philodina* and a leech, as between those of any other of the Rotifera and the skipping motions of Entomostraca. The figure is no actual evidence of affinity: no perceptible likeness exists between fixed Rotifera, or a sac-like *Notommata* and a Crustacean, whilst, on the contrary, an undoubted similarity prevails between a *Stephanoceros* and a Bryozoon; and between *Notommata tardigrada* and many of the Vermes the resemblance is more pronounced than that between any of the Rotatoria and a water-flea. Besides, there are Vermes of a smooth, oval, discoid, and expanded figure, and others with bodies not less clearly divided into regions than the Rotifera.

An annulate articulation, like that of the pseudopodium of Rotifera, is also a feature seen among Annelida; and the telescopic joints and movement are witnessed in *Eunice.* It is the possession of limbs, each consisting of several segments, which is characteristic of Articulata, both in the full-grown and in the larva condition, and not an asymmetrical process actually forming but a single segment. Further, spines and hooks, in some degree moveable like the pincer-processes on the pseudopodium of Rotatoria, occur in many Vermes, especially among the parasitic species. Lastly, a pair of jointed locomotive organs is never found among Rotatoria at any period of their existence. The assertion that the thickening of the integument as a lorica is not seen in any Vermes is correct, if the constitution of the lorica of one piece be a necessary feature, although the thick cartilaginous tube of *Gordiaceæ* and the firm integument of many other Annelids may be adduced as analogous conditions. But if a lorica may be composed of several pieces, the whole family of marine Annelida, in which the skin is hardened into a firm shield, may be cited as homologous. To Leydig's remark that he knows of no Vermes with a lorica, the rejoinder may be made, that no Crustacean is found enveloped in a gelatinous sheath, like *Notommata centrura*, whilst, on the contrary, such an investment is common among Vermes, and especially exemplified in *Siphonostomum.*

Striated muscles are not unknown in Annelida; they have been seen in *Salpa*; and in some Radiata the particles of muscles separate as so many disks. Moreover, such muscles occur in other Invertebrata besides Crustacea, and they therefore furnish no real argument for allying Rotifera with the latter.

The nervous system lends no support to Leydig's views, as he professes it does. A coalesced cerebral ganglion sending off nerves to depressions in the cuticle armed with bristles, finds no analogy among the lower Crustacea, but exhibits, on the other hand, an actual identity of structure with the nervous system of the Turbellaria. The same resemblance is apparent among all the Cestoidea, the *Nemertæ*, *Planariæ*, and Trematoda. Again, the like degrees of development of eye-specks, from a simple heap of pigment to a definite organ with a refracting medium, is illustrated by all those sections of the class Vermes, as Quatrefages shows in his figures of the *Nemertæ*. The mode of termination of the nerves described by Leydig in Rotatoria and Crustacea is also seen in Vermes;' and in general the organization of the nervous system is much more in accordance with that of Cestoidea than with that of the lowest Crustacea. Leydig remarks the great similarity of the maxillary apparatus of young *Daphniæ* with that of some Rotatoria, but forgets that a similar structure occurs in many Vermes. On the other hand, there are no Crustacea which can, like several *Notommatæ*, protrude the maxillary organs as prehensile instruments; yet it is a common phenomenon with many Vermes. Further, in no Articulata are the anus and rectum wanting, as happens with some Rotatoria; for although in the larva of *Myrmeleo*, as Leydig states, the rectum is transformed into a spinning organ, still the viscus is present, though modified for a different functional purpose: however, among Vermes such an imperfect intestinal canal is common enough. From the preceding considerations, the structure of the alimentary tube must be admitted to accord rather with that of Vermes than with that of Crustacea.

The secreted solid matter in the cloaca of embryo *Cyclops*, compared by Leydig to the "urinary concretions" of Rotifera, is, however (unlike them), produced originally of a green colour, within a sac on each side of the intestine, but subsequently becomes yellow, and is discharged through the cloaca. Such sacs or cells have rather the signification of a liver, and are common among Vermes.

Leydig relies most on the phenomena of the sexual system and the occurrence of distinct male animals. But *Polynoë*, *Exogone*, and the *Cystoneidæ* produce both summer and winter ova, and carry them about. And with reference to the existence of small distinct males, Krohn has proved it in *Autolytus prolifer*, whilst among Nematoid worms generally a marked difference obtains between the males and females; and what, indeed, can be more striking than the difference between *Distoma Okenii* and *D. hæmatobium*? The variation in form and structure between the two sexes can therefore furnish no differential character, seeing that it occurs alike in some Crustacea and in most bisexual Vermes.

The occurrence of a metamorphosis, and the shrivelling or obliteration of the eyes, are phenomena common to Vermes and Crustacea. The larval *Stephanoceros* is equally comparable and similar to the occasional type of Annelid larva, having a frontal ciliary wreath in advance of the eyes, or otherwise to the larvæ of *Nemertidæ*, such as *Alardus caudatus*, as to the embryos of any Crustacea. Wherefore all Leydig's characters, even where they indicate some affinity with the Crustacea, exhibit, at least, an equally close one with Vermes.

The presence of vibratile cilia and the peculiar respiratory organs are, as Leydig admits, circumstances approximating Rotifera to Annelida. A tortuous canal with ciliated tags occurs in none of the Articulata, and is inconsistent with the type of their water-breathing apparatus. At best there is only a remote analogy, whilst a close similarity, and even an identity, is seen between such structures and those of most Cestoidea.

The history of development is in favour of the Annelid alliance, and opposed to Leydig's hypothesis; for in all Crustacea the embryo originates from a primitive part superposed upon the yolk, whilst in Rotifera, in common with all Vermes, such a supplementary part is wanting, and the embryo is generated from the entire yelk.

The appeal to metamorphosis lends its support to the present argument: for no trace of resemblance is perceptible between the larvæ of such Crustaceans as undergo transformation, having three pairs of jointed legs or feet, and the embryo stages of Rotatoria—for instance, of *Stephanoceros*, with ciliary wreath, posterior bunch of cilia, lateral eyes, and vermiform trunk; yet in all these particulars it, on the contrary, assimilates to the larvæ of Vermes, between which and the adult state the diversity is equally great.

The accompanying tabular statement given by Vogt briefly presents the chief points of the discussion.

SYSTEMATIC POSITION OF THE ROTATORIA.

Characters inconsistent with Crustacea but in accordance with Vermes.	Characters common to Crustacea and Vermes.	Characters inconsistent with Vermes.	Characters peculiar to Crustacea.	Characters not exclusive but common to other classes.
1. Ciliary motion.	Annulation of the bodies with telescopic segments.	....	....	Formation of a lorica.
2. Vessels with ciliated tags.	Structure of the nervous system and organs of sense.	....	....	Structure of the muscles.
3. Development of embryos from the entire yelk without primitive part.	Maxillary apparatus.	....	....	Structure of intestinal canal.
4. Typical structure of the larvæ and young, without jointed locomotive organs.	Formation of eggs and their carrying about by parent.	....	....	Urinary secretion (?).
5. Total absence of articulated limbs in pairs during their entire existence.	Dissimilarity and imperfect organization of the males.			

Cohn's name may now be added to the list of opponents to the Crustacean alliance. We have already seen (p. 447) that he denies the occurrence of any metamorphosis in the course of development of the Rotatoria, and by so doing sets aside one indication Leydig brought forward in favour of their alliance with Crustacea. The following is a summary of his arguments against that relationship:—"The ciliated condition of the Rotifera, their respiratory apparatus, their nervous system, the position of the intestine, and even their general form, are all of them circumstances in favour of their affinity with Vermes." Cohn can find no true articulations, but merely shallow folds of the skin in the principal portion of the body; and even the pseudopodium and toes are not articulated motory organs (or limbs), but prolongations from the common cavity of the body. The circumstance of his having united the Tardigrada with the Systolides (Rotatoria) indicates Dujardin's recognition of the affinity of the latter with Crustacea; for in structure the Tardigrada make an unmistakeable approach to Arthropoda by the pairs of limbs and chain of ganglions on the abdominal surface, and to Arachnida also by the structure and disposition of their digestive organs, by their suctorial mouth, and by other details of organization. Their association with Rotatoria, however, is not recognized by any other naturalist besides Dujardin; and they are generally placed amongst the lowest Arachnida, near the *Pycnogonidæ* and *Acarinæ* (the lowest families of Arachnida) (see Section V., OF THE TARDIGRADA).

A still higher affinity has been recently claimed for the Rotatoria by Mr.

Gosse, viz. with Arthropoda and Insects. He supports this notion by an appeal to the structure of the maxillary apparatus and to supposed analogies of its several parts with the mandibles, jaws, &c., of insects. The "mastax" (see chapter on Digestive Apparatus) he identifies with a true mouth; the "mallei" with mandibles; the "manubria" possibly with the cheeks, into which the "mallei" are articulated; the "rami" of the "incus" with maxillæ; and the "*fulcrum*" he imagines to represent the "*cardines*" soldered together. While maintaining this connexion with Insecta through the maxillary organs in their highest development, he suggests their affinity with Polyzoa by the same organs at the opposite extremity of the scale, since the oval muscular bulbs in *Bowerbankia* approach and recede in their action on food, and seem to represent the quadriglobular masses of *Limnias* and *Rotifer* further degenerated. If this affinity be correctly indicated, the interesting fact is apparent that the Polyzoa present the point where the two great parallel divisions Mollusca and Articulata unite in their course towards the true Polypi (see Mr. Gosse's valuable paper in the *Philosophical Transactions*, 1855). In a memoir since read before the Royal Society (*Phil. Trans.* 1857) by this same distinguished naturalist, the Crustacean alliance is further insisted on upon the ground of the sexual peculiarities of the Rotatoria. In this paper the author remarks that we must look, for a parallel to the curious facts established concerning the diœcious character of Rotifera and their peculiar males (see p. 455), to the Crustacea. "The economy of the *Hectocotylus* of certain Cephalopod Mollusca, though perhaps even still more abnormal, is only remotely analogous. Nor is the parallelism very close of those Entozoa in which the males are organically united to the females, as the genera *Heteroura* and *Syngamus*, described by Professor Owen.

"In the class Crustacea, however, many examples occur of a sexual difference, which may instructively be compared with the one before us. Thus, among the Isopoda, we find the parasitic genera *Bopyrus*, *Phryxus*, and *Ione*, in which the males are notably smaller than the females, very diverse in form, and in some respects inferior in structure. In the Siphonostoma 'the males are extremely small, and do not in the least resemble the females,' though those of different genera bear a strong resemblance *inter se*, even when the females are very dissimilar. So low is their grade of organization, that Burmeister has attempted to prove these minute creatures to be embryonic or larval forms. And, finally, in the Cirripedia, Mr. Darwin has proved the existence of males in the genera *Ibla* and *Scalpellum*, which are very minute as compared with their females, excessively abnormal in form, and in some respects in an embryonic condition, though unquestionably mature, as shown by the spermatozoa. And, what is still more interesting, the same accurate zoologist observes—'After the most careful dissection of very many specimens, ... I can venture positively to assert that there is no vestige of a mouth or masticatory organs, or stomach.' Again, he describes the internal structure as 'a pulpy mass with numerous oil-globules,' and the sperm-vesicle as 'a pear-shaped bag at the very bottom of the sack-formed animal, containing either pulpy matter, or a great mass of spermatozoa,'—terms which might have been employed in describing some of the male *Brachioni*.

"In all these analogies I conceive we may find additional reasons, to those that have been before adduced, for assigning to the Rotifera a zoological position among the Articulata."

The attempt of Mr. Gosse to identify parts of the maxillary mechanism of Rotatoria with that of Insects, although praiseworthy, is in our opinion unsuccessful, and involves a considerable stretch of imagination. Moreover, if the identifications, or more correctly speaking the homologies, be correct, we do not see that this circumstance is *per se* adequate to establish an alliance with the Insecta, particularly when, in most other respects, the differences between the two groups of beings are so very considerable. Referring only to the particulars mentioned in Vogt's critique, we may observe that if the aberrations of organization of Rotatoria from the lowest Crustacea render their alliance with the latter more than doubtful, still less possible is their connexion with the highest Articulata, in which every differential character becomes more developed.

The arguments and illustrations of Vogt in favour of the close affinity of Rotatoria with Vermes will to most minds appear convincing; but should any demand further evidence, it is supplied by the opinions of the majority of naturalists and by the reasons adduced in their support. At present we will confine ourselves to the views and arguments of Perty, Siebold, Williamson, and Huxley.

Perty enters into no discussion, but merely states generally that the position of Rotifera with Vermes is indicated by their want of jointed feet in pairs, and of a ganglionic abdominal chain such as Crustacea have, whilst, on the contrary, they are provided with external voluntary and internal involuntary cilia, after the type of Vermes. The class to which he would refer them is that of the Thoracozoa (Arthrozoa).

Siebold affirmed that the affinity of Rotifera with the Crustacea is but remote, since they are, he conceives, deficient of a distinct abdominal membrane, of limbs in pairs, and of striped muscular fibre,—undergo no metamorphosis like Crustacea,—have organs of respiration (cilia) both externally and internally, and an epithelium lining the alimentary tube, such as no Arthropoda or Crustacea possess. Subsequent research has invalidated a few of the reasons put forward by Siebold, such as that of the absence of striated muscles; but the majority retain their force.

Prof. Williamson argues, from the particular instance of *Melicerta*, against a Crustacean relationship. His words are—"In the possession of so highly-organized a form of voluntary muscle, in the investment of the fasciculi by a sarcolemma, and in the existence of a well-defined, ciliated, cellular epithelium lining the alimentary canal, we have indications of an organization approaching that of the lower Articulata. The dental apparatus appears to constitute a splanchno-skeleton, like that of the Crustacea; but, on the other hand, the absence of a visible nervous system removes the *Melicerta* far below the Homogangliate animals. That they should possess a nervous system of some kind appears almost a matter of necessity if the presence of a striated muscular fibre indicates volition; but its actual existence has yet to be demonstrated. I have found no special organs of circulation or respiration. On watching the movements of the small free cells which float in the visceral cavity, as well as in the tail, it becomes obvious that the fluid contained within the integument moves freely with every contraction of the body. I detect no vessels or pulsating organs. These facts also tend to associate the animal with the Acrita rather than with the Homogangliate Crustacea. At the same time its organization is of a higher type than that of the Bryozoa. ....Again, many Vermes possess horny jaws not wholly unlike those of Rotatoria, together with similar stomach-glands, equally resembling those of some lower Crustaceans; and, moreover, many Vermes, *e. g. Clepsine*, carry their eggs about with them."

Prof. Huxley has very ably examined the question of the affinities of the Rotatoria. Containing, as his opinions and illustrations do, many additional facts, we shall, at the risk of some repetition, add them to the preceding discussions and details. In the first place, he adopts, as a group of the lower

Annulosa, under the name of Annuloida, the several families Annelida, Echinodermata, Trematoda, Turbellaria, and Nematoidea, and in company with these he would place the Rotifera. "The terms of resemblance (to the Annuloida) are these:—1. Bands of cilia, resembling and performing the functions of the wheel organs, are found in Annelid, Echinoderm, and Trematode larvæ. 2. A water-vascular system, essentially similar to that of Rotifera, is found in Monœcious Annelids, in Trematoda, in Turbellaria, in Echinoderms, and perhaps in the Nematoidea, the Cestoidea, and the Nemertidæ. 3. A similar condition of the nervous system is found in Turbellaria. 4. A somewhat similarly armed gizzard is found in the Nemertidæ; and the pharyngeal armature of a Nereid larva may well be compared with that of *Albertia*. 5. The intestine undergoes corresponding flexures in the Echinoderm larvæ. There are therefore no points of their organization in which the Rotifera differ from the Annuloida; and there is one very characteristic circumstance, the presence of the water-vascular system, in which they agree with them."

Prof. Huxley next proceeds to inquire to which of the Annuloida the Rotifera are most closely allied, and in so doing seeks for the fundamental types of their organization by an ingenious mode of demonstration, adducing the genera *Stephanoceros, Philodina, Notommata, Brachionus,* and *Lacinularia* as "the types of the great division of the Rotifera, and of which whatever is true will probably be found to be true of all the Rotifera." The result he arrives at is, "that the Rotifera are organized upon the plan of an Annelid larva, which loses its original symmetry by the unequal development of various regions, and especially by that of the principal ciliated circlet or trochal band." After some further remarks, Prof. Huxley adds—"I do not hesitate to draw the conclusion" (which at first sounds somewhat startling) "that *the Rotifera are the permanent forms of Echinoderm larvæ*, and hold the same relation to the Echinoderms that the Hydraform Polypi hold to the *Medusæ*, or that *Appendiculariæ* hold to the Ascidians.

"The larva of *Sipunculus* might be taken for one of the Rotifera; that of *Ophiura* is essentially similar to *Stephanoceros*; that of *Asterias* resembles *Lacinularia* or *Melicerta*."

Again, this talented naturalist believes that the Rotifera furnish the link between the lower Echinoderms (which otherwise seem to lead nowhere) and the Nemertidæ and Nematoid worms, the Rotifera themselves forming the lowest step of the Echinoderm division of the Annuloida, the proposed subkingdom of Cuvier's Radiata.

To elucidate his views, Prof. Huxley has appended to his essay a series of diagrams showing the essential correspondence between Rotifera and Annelid or Echinoderm larvæ.

When Leydig wrote his memoir on the Rotatoria, he had the advantage of seeing this contribution to their history by Prof. Huxley, and has remarked in general terms, of the above views and their illustrations, that although the ingenuity of the attempt to prove Rotatoria permanent larvæ of Echinoderms must be admitted, he is nevertheless unable to adopt the hypothesis of the English observer, and must hold to his own idea of their Crustacean character.

The conclusion which it seems to us must be adopted is, that the Rotatoria belong to the great group of the Radiata known as Vermes, and stand in more particular relation with those families which make up the proposed division "Annuloida."

We must now add a few observations concerning the affinity exhibited by the Rotatoria with the Ciliobrachiate Polypes or Bryozoa (a family of Polyzoa).

This affinity is particularly marked in the genus *Stephanoceros* on the part of the Rotifera, and in that of *Bowerbankia* on the side of the Bryozoa. The members of the latter genus live in an elongated tubular case, and have themselves an elongated, rather club-shaped figure. The case is transparent; its upper portion is soft, so that it can close over the animal when retracted. The head of the Bryozoon is armed with several long processes or tentacles similar to those of *Stephanoceros*, which are clothed with cilia and spines; and the margin of the head itself is also ciliated. This whole armature is retractile. Muscles are distinguishable, moving the several parts. The digestive system comprehends a mouth, œsophagus, gizzard, stomach, a gastric tube or pylorus, and an intestine, lined with cilia, returning upwards, so that the anus opens near the mouth. The lining membrane of the gizzard is moreover furnished with many horny teeth, seated on oval muscular bulbs, which, according to Mr. Gosse (see p. 473), "approach and recede in their action on food, and seem to represent the quadriglobular masses of *Limnias* and *Rotifer* further degenerated." The Bryozoa as a class are reproduced by three modes: 1. by ova; 2. by ciliated gemmules; and 3. by budding (gemmation) from the common stem or polypidom where they grow. The second mode is not met with in *Bowerbankia*, but only in species having fleshy or gelatinous polyparies (e. g. *Halodactylus*), where the ciliated gemmules occur in sacs, which appear as whitish points imbedded in the general mass. Is there, we may ask, any analogy between these and the winter ova of Rotifera, which are in some cases ciliated or hairy? The ovary producing the ordinary ova is placed close above the stomach; and contiguous to it is the testis, filled with spermatozoa. The ova when ripe escape into the general cavity of the body, where they are surrounded and impregnated by the spermatozoa; and after several have accumulated about the base of the tentacles, they are at length discharged through the anus. The ova are remarkable from their irregularity of shape. The embryo escapes as a free being, not unlike some ciliated Protozoon, but by-and-by it fixes itself, produces its pedicle, and assumes the form of its parent.

On comparing this description of *Bowerbankia* with that of *Stephanoceros*, the points of similarity between the two are very many and striking. The points in which *Bowerbankia* chiefly differ are—1. its character as a member of a compound mass or polypary from which it may itself have grown as a bud, whilst reproduction by gemmation is unknown among Rotifera; 2. the position of the ovary above the stomach, in close proximity, with an evident testis; 3. the apparent absence of an oviduct, and the consequent escape of the ovum, followed by its fertilization, within the general cavity of the body; 4. the imperfect development of a maxillary apparatus; 5. the absence of a water-vascular system; 6. the greater length and stiffness and more slender figure of the tentacles or arm-like processes of the head; and 7. the different disposition of the cilia upon them—for these in *Stephanoceros* are arranged in little bunches or whorls at short distances from each other.

But several of these distinctive particulars lose much of their force from other comparisons and considerations. Thus the absence of an oviduct is admitted as an occasional event in Rotifera; and the escape of the embryos into the general cavity of the body has been stated by many observers to occur in *Stephanoceros*; Leydig, however, denies this; yet the birth of the young in *Philodina* and their active life within the body of the parent may present the analogy in request. It cannot be affirmed with certainty that *Bowerbankia* is unlike *Stephanoceros* in having a testis in company with the ovary; for no male *Stephanoceros* has yet been found, and some doubtful structures have been by some assumed to represent the testicle. To cite yet another circumstance, a water-vascular system is indistinct in *Stephanoceros*, and would be overlooked, as Leydig remarks, did not the knowledge of its form and of its existence in other Rotatoria direct in the search for it; and, on the other hand, such a structure has not been sought after in *Bowerbankia*.

These and other considerations, which might easily be added to, lessen the differential characters, and, together with the many undoubted points of resemblance between *Bowerbankia* and *Stephanoceros*, incline us to the very prevalent opinion that there is a real affinity between Rotifera and Bryozoa, although we would not go so far as some naturalists and place the genus *Stephanoceros* among the latter.

Huxley entertains an adverse opinion, and believes that "there is a fundamental error in approximating the Polyzoa and the Rotifera at all, that the resemblance between *Stephanoceros* and a Polyzoon is very superficial, and that the relations between the Polyzoa and the Rotifera are at the best mere analogies."

The resemblances between the Rotatoria and the Ciliated Protozoa are merely superficial. *Vaginicola* is enclosed in a transparent sheath, like a *Floscularia* or a *Tubicolaria*; the urceolated individuals of *Ophrydium* are grouped into gelatinous balls, like those of *Conochilus*; the ciliary wreath about the head of *Vorticella, Stentor*, and *Vaginicola* makes an approximation to that of Rotatoria; and the contractile muscular pedicle of *Vorticella* and *Zoothamnium* recalls, in some respects, the retractile pedicles of the fixed Rotatoria.

A connecting link is, however, supplied between the Ciliated Protozoa and the Rotatoria by most genera of the family *Ichthydina*, which Ehrenberg indeed numbered among the latter class. This great microscopist had but an imperfect acquaintance with their organization; and at the present time our knowledge of it is far from complete. The genera referred to are *Ichthydium* and *Chætonotus*; and perhaps Mr. Gosse's genus *Sacculus* should be united with them. The genus *Glenophora* of Ehrenberg is not recognized by most naturalists.

They differ from Rotatoria in having no transverse joints or folds to the body, no water-vascular system, no appreciable muscles or nerves, whilst the ciliary wreath is on the model of Ciliated Protozoa, and the alimentary canal after the type of that of Nematoda and of Anguillula. The vibratile cilia extend also over the abdominal surface of *Ichthydium*, and over both the ventral and dorsal of *Chætonotus*. Lastly, according to M. Schultze they are hermaphrodite, and have pin-shaped spermatozoa. These peculiarities of organization have induced observers generally to exclude these genera from Rotatoria. Dujardin has found a place for them along with *Coleps*; and a doubtful subgenus he named *Planariola*, as a subclass of Ciliated Protozoa, unlike the rest of this class in being symmetrical.

Another link between Rotifera and the Ciliata is to be found in the peculiar genus *Dysteria*, which Prof. Huxley referred to the *Euplota*, and Mr. Gosse to the *Monocercadeæ* among the Rotatoria (see p. 387).

Classification.—Since no observers, prior to Ehrenberg, duly recognized the Rotatoria as a class distinct from the Protozoa, we may at once commence with an analysis of the classification he has proposed.

This was based on the apparent structure of the rotary organ, of which he distinguished two types: 1. in which the circlet of cilia is complete—*Monotrocha*; 2. in which it is divided into two or more segments—*Sorotrocha*. Each typical form was subdivided; the first into *Holotrocha*, in which the ciliated ring is entire, and *Schizotrocha*, in which the wreath is notched. The second (*Sorotrocha*) into *Polytrocha*, with a compound wreath of several lobes or secondary circlets, and into *Zygotrocha*, where the organ consists of two (a pair of) symmetrical wreaths.

The further division of these sections into families was founded on the circumstance of the animals being either loricated or not loricated; and the distribution into genera was made, primarily, according to the number and disposition of the red eye-specks, and in a secondary degree, according to the characters of the jaws and teeth, or of those of the foot-process, or otherwise, more rarely, of the lorica.

This classification we present in a tabulated form for convenience of reference.

CLASS ROTATORIA, ACCORDING TO EHRENBERG'S SYSTEM.

SECTION I. MONOTROCHA.

	FAMILIES.				GENERA.
Holotrocha.	Illoricated: Ichthydina	eyes absent	hair absent	with truncated foot	Ptygura.
				with forked foot	Ichthydium.
			hair present		Chætonotus.
		eyes present			Glenophora.
	Loricated: Œcistina	loricæ distinct			Œcistes.
		loricæ agglomerated			Conochilus.
Schizotrocha.	Illoricated: Megalotrochæa	eyes absent			Cyphonautes.
		eyes present	one eye		Microcodon.
			two eyes		Megalotrocha.
	Loricated: Flosculariæa	eyes absent			Tubicolaria.
		one eye (when young)			Stephanoceros.
		two eyes (when young)	rotary organ bifid	urceoli distinct	Limnias.
				urceoli agglomerate	Lacinularia.
			rotary organ 4-fid		Melicerta.
			rotary organ 5–6-fid		Floscularia.

SECTION II. SOROTROCHA.

Division I. Polytrocha.

Illoricated.	Hydatinæa.	eyes absent	no teeth			Enteroplea.
			teeth	jaw many-toothed		Hydatina.
				jaw one-toothed		Pleurotrocha.
		one eye	frontal			Furcularia.
			cervical	foot styliform		Monocerca.
				foot furcate	frontal cilia alone	Notommata.
					do. with styles	Synchæta.
					do. with uncini	Scaridium.
				foot absent; body with lateral cirrhi		Polyarthra.
		two eyes	frontal	foot furcate		Diglena.
				foot styliform	cirrhi on neck	Triarthra.
					cirrhi wanting	Ratulus.
			cervical	foot furcate		Distemma.
		three eyes				Triophthalmus.
						Eosphora.
						Otoglena.
		eyes numerous				Cycloglena.
						Theorus.
Loricated.	Euchlanidota	eyes absent				Lepadella.
						Monostyla.
						Mastigocerca.
						Euchlanis.
						Salpina.
						Dinocharis.
						Monura.
						Colurus.
						Metopidia.
						Stephanops.
						Squamella.

DIVISION II. ZYGOTROCHA.

	FAMILIES.					GENERA.
Illoricated.	Philodinæa	eyes absent	with a proboscis and foot-processes			Callidina.
			without proboscis; no horn-like processes on the foot	rotary organ pedicled		Hydrias.
				do. not pedicled		Typhlina.
		eyes present	two frontal	foot with horn-like processes	terminal toes two	Rotifer.
					do. three	Actinurus.
				foot without such processes; terminal toes two		Monolabis.
			two cervical			Philodina.
Loricated.	Brachionæa	eyes absent	foot furcate			Noteus.
		eyes present	one (cervical)	foot absent		Anuræa.
				foot furcate		Brachionus.
			two (frontal), foot styliform			Pterodina.

Many serious objections attach even to the fundamental principles which Ehrenberg has adopted in his systematic distribution of Rotifera. Leydig has well argued against the existence of an actually compound trochal disk (p. 398); and to designate the peculiar ciliated organs of *Floscularia* and *Stephanoceros* simple notched wreaths is certainly a misnomer, and conveys an erroneous impression.

The employment of the "loricated" and "illoricated" condition, as understood by Ehrenberg, in the construction of families, is even more faulty; for, as before observed (p. 394–5), he uses the term "lorica" so loosely, that it designates no one special structure. The existence and position of eye-specks, as characteristic of genera, are very uncertain and insufficient. These coloured specks, especially when numerous, are not constant either in number or position; they disappear with age in numerous instances, in some even before the adult condition is attained; they may be deficient from various external circumstances of development; and, in general, they have not that importance in the organization and life of the Rotatoria which can warrant their employment as generic distinctions. The formation of the jaws and the number of the apparent teeth might afford valuable characteristics; but they are facts difficult of determination on account of the minuteness of their parts. From the above considerations it is evident that the descriptions of the Berlin Professor are open to much question, and the generic characters based on them uncertain.

That this artificial system of Ehrenberg is erroneous, is also evidenced by the separation of undoubtedly allied forms which it often entails. This evil involves another, that of the unnecessary multiplication of genera and of distinctive names. Thus Dujardin rightly insists on the erroneous distribution of a naturally single genus, from the really unimportant variation in the number of coloured specks, into the several genera *Lepadella*, *Metopidia*, *Stephanops*, and *Squamella*; and also indicates the division of the families *Philodinæa* and *Hydatinæa* as carried too far. On the other hand, the extensive genus *Notommata* comprehends many very dissimilar animals, including, for instance, not only such as possess the typical alimentary canal of the Rotifera, but also those recently discovered forms that diverge from that type in wanting a separate anal outlet. Such a genus requires revision. The same may be said of the genus *Diglena*. In the opinion of many naturalists, the Berlin Professor falls into an additional error in admitting the family *Ichthydina* among the Rotatoria. In fine, the result of modern research is to call equally in question several of the subdivisions and genera which he has instituted.

Although the defects and errors of Ehrenberg's system be generally admitted, yet several writers, such as Siebold, Perty, and Gosse, have been content to employ it in the absence of a better. Indeed, before a correct natural classification of the Rotatoria can be made, the organization of each independent form must be investigated, and the signification and relative importance of its parts determined.

Various temporary arrangements have been suggested. Ehrenberg himself indicated a division of the class according to the form and disposition of the alimentary canal, and another according to the structure of the dental apparatus. Both these are unsatisfactory and artificial; and even their author was compelled to admit that genera and species were thereby associated in alliances quite different from those they occupied in his accepted system.

Dujardin considers that, "in the present state of science, we do not possess the elements of a definite classification;" and therefore proposes, as a merely provisional scheme, four grand divisions of the Rotatoria, including the Tardigrada: viz., 1. those which live fixed by their posterior extremity; 2. those which have but one mode of locomotion, and are always swimmers; 3. those which enjoy two modes of progression—by crawling, after the manner of leeches, and by swimming; 4. those which creep by moveable uncini on their lower surface, and are destitute of cilia. It is the Tardigrada which constitute this fourth division; and they so far differ from Rotatoria, particularly in the absence of a ciliary apparatus and the presence of rudimentary feet, that their alliance with the latter is generally objected to; even Dujardin himself views it as of doubtful propriety.

The classification of Dujardin, omitting the Tardigrada, is as follows:—

	Families.
1. Fixed forms	FLOSCULARIENS. MELICERTIENS.
2. Having one mode of locomotion, viz. by swimming......	BRACHIONIENS. FURCULARIENS. ALBERTIENS.
3. Having two modes of locomotion: 1. by swimming; 2. by crawling	ROTIFÈRES.

For the further division into genera we must refer to Dujardin's work. The system, as Leydig remarks of it, is founded on a correct principle, and recommends itself by its simplicity. The groups of individuals it brings together generally consort by natural affinities; still some are exceptional and aberrant, and occur as *disjecta membra*.

Leydig makes the attempt to form a division, primarily according to the form of the body, and secondarily, to the nature and the presence or the absence of the foot-process. There are three primary forms:—1. in which the figure is club-shaped or cylindrical; 2. in which it is saccular; 3. in which it is compressed. The accompanying plan represents in full the system in question. The *Ichthydina* are omitted.

LEYDIG'S CLASSIFICATION.

A. Figure club-shaped or cylindrical.

I. *With a long, transversely wrinkled, attached foot.*

In this section are comprised the families *Œcistina*, *Megalotrochæa*, and *Flosculariæa* of Ehrenberg, excepting the genera *Ptygura*, *Glenophora*, *Cyphonautes*, and *Microcodon*. The last belongs to another section; and the other three are incomplete forms.

II. *With a long, jointed, telescopic, and retractile foot.*

Is represented by the family *Philodinæa* (Ehr.).

III. *With a long, jointed, not retractile foot.*

Includes the genera *Scaridium* and *Dinocharis* (Ehr.).

IV. *With a short foot and long foot-processes.*

Includes the genera *Monocerca*, *Furcularia*, and *Microcodon* (Ehr.), and the species *Notommata Tigris* and *N. longiseta* (Ehr.). Leydig surmises that *Microcodon* is a male animal.

V. *With a short foot; the foot-processes equal to the foot in length, or but slightly shorter or longer.*

Comprises the genera *Hydatina, Pleurotrocha, Diglena, Ratulus, Distemma, Triophthalmus, Eosphora, Cycloglena, Theorus, Synchæta* (Ehr.), and *Lindia* (Duj.); together with the species *Notommata Tuba, N. petromyzon, N. saccigera, N. Copeus, N. centrura, N. brachyota, N. collaris, N. Najas, N. aurita, N. gibba, N. ansata, N. decipiens, N. Felis, N. parasitica, N. tripus* (Ehr.), *N. tardigrada* (Leydig), *N. vermicularis* (Duj.), *N. roseola* and *N. onisciformis* (Perty), and the *Furcularia Rheinhardtii* (Ehr.), which is, however, actually a *Notommata*. The genus *Lindia* (Duj.) is doubtful; and that of *Enteroplea* (Ehr.) is the male of *Hydatina senta*.

VI. *Without a foot.*

Is represented by the genus *Albertia* (Duj.).

B. Figure saccular.

I. *With a short foot.*

Such are the species *Notommata clavulata?, N. Myrmeleo, N. Syrinx*, and *Diglena lacustris*.

II. *Without a foot.*

Includes *Notommata anglica* (Dalrymple), *N. Sieboldii* (Leydig), *Polyarthra platyptera* (Ehr.), and the genera *Triarthra* (Ehr.) and *Ascomorpha* (Perty).

C. Figure compressed.

a. Compressed horizontally.

I. *With a foot.*

Represented by the genera *Euchlanis, Lepadella, Monostyla, Metopidia, Stephanops, Squamella, Noteus, Brachionus, Pterodina* (Ehr.), and *Notogonia* (Perty).

II. *Without a foot.*

The genus *Anuræa* (Ehr.).

b. Compressed laterally.

Includes the genera *Salpina, Mastigocerca, Monura*, and *Colurus* (Ehr.).

This arrangement of the Rotatoria the author confesses to be defective. In our opinion, it has no advantage over the scheme of Dujardin, and, on the other hand, wants its simplicity. Its basis is not such as will combine the species according to their natural affinities; for there is no necessary or direct relation between external form and internal organization, and it is on the latter alone than any classification can securely repose.

SECT. V.—OF THE TARDIGRADA.

THEIR STRUCTURE, HABITATS, AND AFFINITIES.—The Tardigrada or Tardigrades (in German, *Wasserbären*, lit. *water-bears*) constitute a small group of animals, first noticed by Eichhorn, and latterly more fully investigated by Doyère, Dujardin, and Kaufmann.

Their size is so considerable (from $\frac{1}{20}$th to $\frac{1}{50}$th of an inch in length) that they are visible to the naked eye. They have oblong, symmetrical, non-ciliated, and very contractile bodies, admitting of their rolling themselves into a ball, and of otherwise varying their figure. The head is somewhat produced, assuming a conical or pyramidal figure; but they have no pseudopodium or other posterior process.

They are invested by a resistant, firm, and sometimes horny integument, composed of two layers. The firmness is due to the chitinous composition of the external lamina or cuticle, which is not affected by caustic alkali. In *Emydium*, M. Doyère describes the integument to consist of four horny plates. During contraction, the integument is thrown into transverse folds, and the anterior and posterior segments retracted. Its surface is generally smooth; but in *Emydium* there are a few pretty regularly disposed bristles (setæ) on the back and sides; and in the neighbourhood of the mouth there are, as a rule, several soft flexible processes, palpi or antennæ. Numerous and definite muscles extend between the inner skin or epidermis and the various organs and members.

The under or abdominal surface is clearly distinguished from the dorsal by the presence of four pairs of rudimentary feet without joints, each consisting of a nipple-like (mammilliform) process supporting on its extremity from two to four well-developed curved and acute uncini or hooks. These are the locomotive members by which the animals crawl upon and adhere to solid substances.

The head is without a trochal disk or ciliary wreath, vibratile cilia being entirely wanting. The mouth, opening at its extremity, in the median line, is modified so as to form a sucking-tube; it is narrow, and drawn out to a more or less fine extremity; it is bounded on each side by a lateral, rigid, horny, narrow or linear process—the maxilla, which is moveable upon a single or double central piece or fulcrum. The whole organ constitutes a tube-like sucker, and is protrusile at will beyond the head, like the suctorial mouths of *Acari* and Insecta. On each side of the mouth are the small retractile palpi already noticed.

The mouth opens posteriorly in a pharyngeal muscular bulb, furnished internally with a horny articulated dental apparatus, serving to crush food, but less highly organized than in Rotifera. Under the polarizing microscope the manducatory organs exhibit the same appearance as horn. From them the food passes into an elongated tubular stomach or intestine, continued straight through the body, and terminating in an anus at the posterior extremity. In its course it presents numerous lateral offshoots or diverticula.

No form of respiratory or circulatory apparatus has been detected; but a multitude of granules and corpuscles are seen to float freely in the general cavity between the integument and the alimentary canal, which Doyère supposed to be concerned in the processes of nutrition, and to be analogous to blood-corpuscles. M. Quatrefages states that the fluid within the body is in perpetual irregular motion.

The nervous system is well developed. It consists of a chain of ganglia, with intercommunicating (anastomosing) nerve-fibres, besides a central or cerebral ganglion.

The eyes are variable and fugacious.. The sense of touch may be presumed to reside specially about the suctorial mouth and its contiguous palpi. All the Tardigrada are hermaphrodite. The ovary is of large size; but the ova, according to Kölliker and Frey, do not in the course of development exhibit a germinal disk: in this they differ from Arthropoda. Few eggs are produced at a time, and are of large size. They are, curiously enough, found in the exuviæ or moultings of the animals; for from time to time the outer skin is cast off. M. Doyère convinced himself of the existence of a testis and spermatozoa. Dujardin says the embryo emerges from the ovum perfect in form; but Kaufmann, on the contrary, affirms that they undergo some degree of metamorphosis ere they attain the adult structure.

The Tardigrada have received their name from their slow movements. They are parasitic animals, and live by sucking the juices from other beings. They are common upon water-plants and vegetable debris in ponds; yet immersion in water is not necessary, since they are found, like Rotifers, in the dust and rubbish on the roofs of houses (a locality in which they were first encountered by Spallanzani), and especially amid the small lichens, mosses, &c., which spring up in such situations. The *Bryum* is a favourite moss for these creatures. On shaking portions of this or of other mosses or aquatic plants in a basin of water, the Tardigrada will fall to the bottom, and may be easily collected.

In most vital phenomena they very closely accord with Rotatoria; thus, like these, they can be revived after being put into hot water at 113° to 118°, but are destroyed by immersion in boiling water. They may be gradually heated to 216°, 252°, and even 261°. It is also by their capability of resuscitation after being dried that they are able to sustain their vitality in such localities as the roofs of houses, where at one time they are subjected to great heat and excessive drought, and at another are immersed in water.

O. Müller (in 1785) seems, from the name (*Acarus Ursellus*) which he imposed on the species he then knew of, to have rightly conceived their natural affinity. Ehrenberg and Schultze (1834) placed them among the *Lerneæ*. Dujardin (in 1841) advocated their alliance with the Rotatoria, and constituted them one of the divisions of that class, under the name of "*Systolides Marcheurs*," or creeping Rotatoria; for he considered them to form a link between the Rotatoria and the Helminthidæ on one side, and the Annelida and Arachnida on the other. M. Doyère at first coincided in this opinion; but his subsequent researches led him to give it up and to constitute the Tardigrades a distinct group. Dujardin himself has, moreover, modified his first opinion, as appears by his memoir in the *Annales des Sc. Nat.* for 1851; for he there remarks that the Tardigrada are equally allied to the Rotifera and to the Nematoid Helminthidæ, and that it is uncertain whether they ought to be referred to Articulata or Vermes. Our countryman Mr. White (in a paper read before the Linnean Society in 1851) stated his belief "that the so-called *Acarus folliculorum*, and probably also Tardigrada, are parasitic Rotatoria, with legs or leg-like appendages adapted to their peculiar habits, and that their retractile, antenna-like, subtelescopic appendages may have eyes passing through them, as in snails, and may also be the equivalents of the *rotæ* (rotary lobes), but, from the limited, or rather the absolutely restricted, power of motion of these animals, have neither the ciliary processes nor the movements and economical uses of the appendages so characteristic of most of the Rotatoria."

Perty tells us that in 1848 he constructed a family *Xenomorphidæ*, which was accepted by Ehrenberg, to comprehend the Tardigrada, the best-known of which were included in a genus *Aretiscon*, so named by Schrank. His opinion now is, that "perhaps they should rather be associated with the class Arachnida, as a lower type, near the Acarinæ," and not be numbered with the Crustacea, as he formerly proposed. "Doyère's figures of *Emydium* indicate their alliance with the Acarinæ, like many of which the *Xenomorphidæ* (Tardigrada) suck the juices of other animals. Their development differs from that of Rotifera; and their skin is composed of chitin." This last distinction, also insisted upon by Kaufmann, vanishes if Leydig be correct in his statement that Rotatoria likewise have a chitinous cuticle.

The most recent writer on Tardigrada we have met with is Kaufmann (*Zeitschr.* 1851, p. 220), who has presented an able memoir on those beings. He indicates the following distinctive features between them and Rotatoria: —The history of their development accords with that of Arthropoda, and disagrees with that of Rotifera: the epidermis is composed of chitin, a substance only found in Arthropoda (this we have already stated is probably an error); the pairs of indistinctly-jointed limbs and the abdominal chain of ganglia no Rotifer possesses, whilst, on the other hand, the Tardigrada have no trochal disk and no vibratile cilia, but possess a suctorial mouth; lastly, they are deficient of a water-vascular system, and are all hermaphrodite.

Cohn, in a recent paper (Siebold's *Zeitschrift*, 1855, p. 481), throws some doubt on this presumed monœcious nature of the Tardigrada. Thus, he says, Doyère, whilst maintaining their hermaphrodite character, has noticed seminal corpuscles (spermatozoa) in only two individuals. On the other hand, he mentions certain examples in which the oral organs were aborted, and both suctorial disk and maxillary head were wanting; this happened most frequently in *Macrobiotus Hufelandii*, and more rarely in other species. Another notable fact is, that in the two closely-allied species, *Macrobiotus Hufelandii* and *Macr. Oberhauserii*, the ova of one are thick-shelled and tuberculated, and those of the other thin-shelled and smooth. In these circumstances Cohn is disposed to find a parallel between Tardigrada and Rotatoria in what relates to their sexual peculiarities,—inferring by this, that, as in the latter family the sexes are separated, and ova of three sorts—male, "summer" (asexual), and "winter"—are produced, so, from the facts indicated, the Tardigrada may also be bisexual (diœcious) and may deposit eggs of each several kind.

The relation of Tardigrada to Arachnida through the lowest divisions of the latter, Kaufmann proceeds to demonstrate by the following particulars:— They have suctorial mouths, like most *Acari*; in the structure and disposition of the digestive organs they agree with Arachnida; by the absence of circulatory and respiratory organs they are allied to the Acarina in part, and to the *Pycnogonidæ* entirely; like many mites (Acarina), they lay few and large eggs. But, again, the occurrence of a metamorphosis to some extent detaches them from the *Pycnogonidæ* and from most Acarina; and they differ from all Arachnida by being hermaphrodite; however, the circumstance of the separation of the sexes, or their union in the same individual, in no class of animals can supply the basis for constituting family distinctions. Even among Arthropoda a family of hermaphrodite animals occurs, viz. the Cirripedia. In this respect the Crustacea and Arachnida, by their lowest members, through which they are linked to other classes of animals, accord; in the former the Cirripedia, which ally them with the Mollusca,—in the latter the Tardigrada, which approximate the Arachnida to the Annelida, bring the two into connexion.

The conclusion therefore is, that the Tardigrada constitute the lowest section of the Arachnida, by the side of the *Pycnogonidæ* and the Acarina.

PART II.

A SYSTEMATIC HISTORY OF INFUSORIA.

[*Note.*—The several groups whose general history is treated of in the first part of this work, viz. Bacillaria (p. 1), Phytozoa (p. 111), Protozoa (p. 199), and Rotatoria (p. 392), being independent of each other, their respective families, genera, and species will not, for the reason stated in the Preface, be described in the same order in this second part, but those of the Bacillaria will be printed last. For an explanation of abbreviations, see end of Contents.]

OF THE GROUP PHYTOZOA (p. 111).

Families:—1. Monadina; 2. Hydromorina; 3. Cryptomonadina; 4. Volvocina; 5. Vibrionia; 6. Astasiæa.

FAMILY 1.—MONADINA.

(Plate XVIII. figs. 1 to 28.)

The Monadina are among the most minute living creatures which have been discovered by man. They are (according to Ehrenberg) destitute of an alimentary canal, are illoricated or shell-less, and have a uniform body without any appendages issuing from it, cilia not being considered as such. They increase by simple and complete self-division into two, four, or more individuals. The uniformity or unvarying appearance in their external form (he says) may be considered as one of the principal characteristics of this family; for no one of the Monadina can voluntarily alter the shape of its body, whether into a filiform, knotty, or globular figure, nor can it extend any portion of it, and then contract it again. All possess organs of locomotion, nutrition, and propagation, the last of the hermaphrodite character. Some of them have a rudimentary eye; but it has never been discerned that they are furnished with a vascular or circulating system, which, however, is not surprising when we reflect that, should they possess it (a supposition by no means to be rejected), the diameters of the tubes of this system would necessarily be of such extreme minuteness as to defy investigation. None but microscopes of high magnifying powers can display their structure; indeed they cannot be observed accurately with a less amplification than 500 diameters, by glasses of considerable penetration and good definition.

The apparent eye of some Monadina is used as a generic character for *Microglena* (XVIII. 6), *Phacelomonas*, &c.; but its possession does not prove the existence of sensibility, although, as Ehrenberg thinks, this faculty is presumable from the alternate vibration and quiescence exhibited by the proboscis when one of these beings is in a place abundantly supplied with food.

The details given in the first part of this work (p. 130), of the nature and structure of the animalcules comprised by Ehrenberg in this family, render it unnecessary here to state more than that the beings so grouped together are heterogeneous both in nature and character, and partake scarcely any other features in common than those of minuteness and the possession of one or of few elongated cilia or filaments as locomotive organs. The deficiency of characteristics necessary to constitute a natural family, and the absence of any proof of the animality of the several genera, were perceived by Siebold, who rejected the Monadina from his group of Infusoria. Agassiz says of them that they are mostly moveable germs of various kinds of Algæ; and in this statement, we believe, as far as relates to the majority, he is correct. Dr. Burnett (*Boston Journ. Nat. Hist.* 1853, vi. p. 319) has the following remarks on these topics:—

"As the family Monadina now stands, it undoubtedly includes very heterogeneous elements, particles being grouped together from their general aspects rather than from their physiological characteristics. I cannot pretend to take them up in that systematic way in which they have been arranged by Ehrenberg; for I have found but little system about them, and for the most part have been unable to follow his descriptions. If we are to judge of them by mere form and size alone, I should say that the varieties they present under the microscope are numberless. Indeed, in watching the same particle for a long time, I have seen it change its form and size four or five times, and each as distinct from the other as many of Ehrenberg's species. Those which contain chlorophyll must, it appears to me, in virtue of that fact, be regarded as of a vegetable nature. As to the others this point would be doubtful."

Again, Dujardin, whilst admitting generally the animal nature of the genera in question, differed widely from the Berlin naturalist both as to their organization and distribution. Since, however, in the present state of our knowledge, it is impossible to fix on the organisms of which they are but developmental phases, it is well, for the purpose of future identification and future researches, to attempt definitions and descriptions of these simple beings, although, as an artificial and temporary proceeding, the whole be doomed to ultimate neglect and destruction. Consequently, we shall retain all Ehrenberg's genera and species, which, however ill-defined and unsatisfactory, give the best representation we possess of these varied and variable microscopic organisms.

The views of Ehrenberg on the special organization of the Monadina have been widely criticised and condemned. The possession of an integument, the fixed invariable outline, and the ocular nature of the red speck, are statements which have encountered the opposition of Dujardin and of very many subsequent naturalists. The existence of a mouth and the reception of coloured food have likewise been widely denied, in accordance with the prevalent hypothesis of their vegetable nature as early phases of Algæ and Fungi; but latterly Cohn has witnessed the entry of coloured particles into their interior,—a circumstance confirmed by Lachmann, who moreover adds that he has twice observed Monadina which contained a small Diatom, the excretion of which, in the vicinity of the posterior extremity, taking place soon afterwards, also made him consider the existence of an anus probable. Schneider remarked in *Chilomonas Paramecium* one or two reddish lines running from the indentation into which the filaments were fixed, to the opposite end, and, from a comparison of these with the process of fission as seen in *Bodo*, concluded that they were furrows which gradually deepen until the animalcule is bisected. As during this process the being undergoes no change of form, except in becoming a little broader, and the division takes place along its whole length, the process must readily escape observation. The anterior end is always a little thicker; the furrows consequently are deeper and more distinctly recognizable in that part. It is only in rare cases, when the division has taken place more slowly in some particular spot, that the two segments must endeavour to tear themselves free, and thus, by twisting in contrary directions, draw our attention to them. It was without doubt a specimen of *Cryptomonas cylindrica* in this condition which Ehrenberg conceived to be two individuals adhering together and not in the act of fissation. Dujardin failed in seeing spontaneous fission among the Monadina, and thinks it more probable that their multiplication takes place by the separation of a lobe or of the termination of an expansion, which his notion that they are without any sort of integument presupposes they may, after the manner of *Amœbæ*, push out from their mass.

The family is distributed into nine genera, as follows:—

Tail wanting	Lips wanting	Swimming	Eye wanting	Single		Monas.
				Aggregate		Uvella.
			Eye present	Single	Proboscis one or two	Microglena.
					Proboscides not more than four	Chloraster.
					Proboscides many	Phacelomonas.
				Aggregate		Glenomorum.
		Rolling				Doxococcus.
	Lips present					Chilomonas.
Tail present						Bodo.

Dujardin was unable to recognize all the genera of Ehrenberg, and believed that *Microglena, Phacelomonas, Glenomorum* and *Doxococcus* appertain to another family, and that the distinction between the genera *Polytoma* and *Uvella* is erroneously deduced from the supposed fission of *Polytoma* in two opposite directions and the periodical grouping of *Uvella*. He thus reduced the genera of Ehrenberg to four in number, viz. *Monas, Uvella, Chilomonas* and *Bodo*, the last comprehending in part his *Hexamita, Amphimonas* and *Cercomonas*. The subjoined table represents the distribution he proposed:—

MONADINA.

Isolated	A Single Flagelliform Filament.	Proceeding from the anterior extremity.	Moveable in its entire length	Monas.
			Thickened, and moveable only towards the extremity	Cyclidium.
		Proceeding obliquely from behind an anterior prolongation		Chilomonas.
	Several Filaments.	A second filament or lateral appendage		Amphimonas.
		A second filament or posterior appendage		Cercomonas.
		Two equal filaments, terminating the rounded angles of the anterior extremity		Trepomonas.
		Four equal filaments in front, two thicker behind		Hexamita.
		A second filament proceeding from the same point as the flagelliform filament, but thicker, trailing and retractile		Heteromita.
	A filament and vibratile cilia			Trichomonas.
Aggregate	Groups always free and whirling			Uvella.
	Groups fixed to the extremity of a branching polypidom			Anthophysa.

"These generic distinctions are, however," Dujardin very justly adds, "entirely artificial, and simply intended to facilitate the naming of Infusoria one may have met with in such and such an infusion, and which, when better known, may prove in some instances only varieties of a single species."

Perty appends to his history of Monadina the following observations:— "Ehrenberg's Monadina are very difficult to determine; many, like *Monas bicolor*, *M. Colpoda*, *M. Enchelys*, *M. Umbra*, *M. hyalina*, *M. ovalis*, *M. Mica*, *M. cylindrica*, *M. deses*, *M. flavicans*, *M. simplex*, *M. inanis*, and *M. scintillans*, appear to be only the earlier stages of other Monadina, or the young stages of Ciliata. *M. Crepusculum* forms my genus *Acariæum*; *M. Termo* is a *Cercomonas*; *M. Guttula* and *M. vivipara* are most likely varieties of the multiform *M. Lens*; *M. grandis* and *Microglena monadina* are Sporozoids; *Monas ochracea*, *M. erubescens*, *M. vinosa*, and probably *M. gliscens* belong to the genus *Chromatium* (XIX. 1); *M. Punctum* is no other than the one filamentary variety of *Polytoma*; *M. socialis* goes along with *Cercomonas*; *M. tingens* is the young condition of *Chlorogonium euchlorum*; *Uvella virescens* possesses one filament and no cilia; *U. Uva* may be a colourless variety of it; *U. Glaucoma* scarcely belongs to the genus *Uvella*, as it has always two filaments *U. Bodo* appears a developmental phase of *Euglena viridis*; *Polytoma Uvella* is equivalent to my *P. Uva*; *Microglena punctifera* is unknown to me. The genus *Doxococcus* I consider untenable; *D. ruber* and *D. Pulviscutus* are merely resting forms of *Astasia*; *Chilomonas Volvox* and *C. destruens* are in all probability embryos of Ciliata, and *Ch. Paramecium* is the hyaline variety of my *Cryptomonas polymorpha*; and *Bodo* is divisible into *Anisonema* (XIX. 8) and *Cercomonas* (XVIII. 11, 12, 20)."

The new genera instituted by the Swiss naturalist are *Tetramitus* (XIX. 3), *Mallomonas* (XIX. 4), *Pleuromonas* (XVIII. 25), *Spiromonas* (XVIII. 24), *Menoidium* (XIX. 2), *Chromatium* (XIX. 1), and *Acariæum*. Fresenius accepts two of these new genera, viz. *Mallomonas* and *Tetramitus*, and creates in addition two others, *Rhabdomonas* and *Grymæa*,—the former not identical with the Rhabdomonads (staff-like monads) mentioned by Ehrenberg as a group of his genus *Monas*.

Respecting the large contribution by Perty to the number of Monadina catalogued by Ehrenberg and Dujardin, the question arises, whether the forms named are really different and distinguishable. We fear, indeed, that the increased number will rather perplex and encumber the observer than advance his real knowledge of microscopic forms. Still, to make our résumé complete, they must be enumerated. In effecting this, the plan pursued will be to describe the several genera admitted by Ehrenberg first, adding the species noted by others, and after these to give the characters of genera and species constituted by Dujardin, Perty, or any other naturalist: where the same being has had a second name given it, it will be added as a synonym. In the systematic details we shall preserve the descriptions and remarks in general which appeared in the last edition, and are largely borrowed from Ehrenberg's most valuable works. These, indeed, are everywhere tinged with the peculiar hypothesis of that writer, the value and bearing of which, however, have been sufficiently examined in the first part of this work to render explanations and corrections here unnecessary. The description, therefore, of mouths, eyes, stomach sacs, glands, vessels, hermaphrodite development, ova, and of all other structures or organs of higher animal organization, will have no other value as applicable to such special organs than that accorded to it in the mind of every individual reader of the chapter on the structure and functions of the Monadina, who can draw for himself his own inferences from the facts and opinions therein recorded.

Genus MONAS (XVIII. 1, 2, 15, 17, 19, 21).—The animalcules of this genus—the true Monads—are described (see table) by Ehrenberg as destitute of an eye, with projecting lip and tail, and as always swimming in the direction of the longitudinal axis of the body, their mouth being situated at the anterior end. It is another distinguishing character of the true Monad, that it is never seen to cluster, like others of its family, so as to form a berry-like mass; and hence it is designated single, in contradistinction. Amongst the several species distinguished, some few are green, yellowish, or of a reddish tint; but the majority are colourless; colour, moreover, is not a characteristic to be relied upon. Monads may often be present in water, under inspection, without being seen, owing to the magnifying power employed being insufficient. They will be sought for in vain with a power of less than 300 diameters; and even this, in some cases, will be found insufficient. They are, besides, as a genus, difficult to be accurately determined, not only on account of their exceeding minuteness, but because the young of other genera are so likely to be mistaken for them,—for instance, the young of the *Bacterium, Vibrio, Uvella, Polytoma, Pandorina, Gonium,* &c., when separated from their clusters. And this difficulty in discriminating them will be more likely to happen when they are not observed whilst undergoing the process of self-division, or when seen in water containing but a small number of them; under which circumstances, however anxious we may be to ascertain their name, we must often rest contented with probable surmise. When the water swarms with the creatures, the decision will be far easier, and more trustworthy, since the characters are then more easily discoverable, and their possible variations appreciable. The observer may, however, be guided to a certain extent by the following rule:—Suppose that in a drop of water containing species of the genus *Vibrio, Bacterium, Uvella,* or *Polytoma* (easily distinguished by their clustering forms), separate Monad-like bodies were to be observed; the probability is that they would be either single forms, or the young of the clustering animalcules; and if there were no great difference in the size of the separate individuals and those forming the clusters, this conclusion would be generally correct: and this rule applies equally to those green Monad-like creatures found amongst *Pandorina* and *Gonium. Chlamidomonas Pulvisculus,* when young, is very deceptive, and may often be mistaken for an illoricated and eyeless green Monad.

The only locomotive organ which has been discovered in the genus is the single filiform proboscis (filament) issuing from near the mouth. The numerous cilia sometimes apparent thereabouts are nothing more than this filament in a state of vibratory or rotatory motion. This organ, Ehrenberg observes, has a twofold office, one being locomotive, and the other to provide the creature with food, and hence may be called a purveying organ.

Vacuoles are readily seen in some of the species (*e.g. M. Guttula* and *M. vivipara*) without the aid of coloured food; in others (*M. Termo, M. Guttula,* and *M. socialis*), its aid is required.

The propagative apparatus Ehrenberg represented in *M. Guttula* and *M. vivipara* to consist of a vast number of granules formed into a net-like mass, dispersed generally throughout the creature, having a comparatively large spherical body (the nucleus) which divides in the process of self-fission.

Monads multiply rapidly by self-division, either transversely, as in *Monas Guttula, M. hyalina, M. gliscens, M. Okenii,* and *M. socialis*; or longitudinally, as in *M. Punctum* (XVIII. 2): both methods have been observed in *M. vivipara.*

As the members of this genus are chiefly curious on account of their extreme minuteness, only the leading characters and size of the several species are given. Most of them are inhabitants of water in which organic matter is undergoing decomposition.

The Monads of Ehrenberg are arranged under two divisions, according to their external form. The first division contains all those of a globular or oval shape (globular Monads); the second those of a lengthened form, the length being more than twice the breadth (elongated Monads).

A.—Globular Monads.

Monas *Crepusculum* (xviii. 1).—The smallest of all living creatures; of a spheroidal form, and hyaline, although, when seen in masses, with the naked eye, of a whitish hue. They are active, and feed on animal as well as on vegetable substances, and are found in water holding animal matter in solution; but as decomposition proceeds, they die, and their bodies rise to the surface of the water, and form a thick and colourless gelatinous stratum. Rarely 1-1200″ in diameter; never larger.

M. *Termo* (M.), so named from its having been supposed to be the limit of animal organization; globular, active, herbivorous; found in stagnant water; increases rapidly where there is an abundance of vegetable matter undergoing decomposition. 1-6000″ to 1-12000″, and less.

M. *Guttula* (M.).—Round, inactive; may be preserved by drying; 12 digestive vacuoles seen by the aid of indigo or carmine; surface appears granulated. In vessels of water containing plants or flowers. 1-2300″ or less.

M. *vivipara.*—Spherical, inactive. In stagnant water; coloured. 1-620″ or less.

M. *grandis.*—Spherical; colour greenish, except near the mouth; filament short, 1-3rd or 1-4th the length of the body; motion sluggish. In marsh water, very rare. 1-430″.

M. *bicolor.*—Globular; colourless, excepting one or two green spots within it; attenuated anteriorly; motion vacillating. 1-1440″.

M. *ochracea.*—Globular; of a yellow-ochre colour. In water-courses. 1-6000″ at most.

M. *erubescens.* — Circular; rose-coloured; motion slow but continued. In salt water. 1-1728″.

M. *vinosa.*—Globular, colour of red wine; motion tremulous; rejects coloured food. In vegetable infusions. 1-12000″ to 1-6000″.

M. *Kolpoda.*—Colourless, oval or egg-shaped; motion vacillating. In water in the silver mines of Siberia. 1-7200″.

M. *Enchelys.*—Colourless; continuous slow motion. In marsh water. 1-1200″ to 1-960″.

M. *Umbra.*—Ovate, colourless; motion rapid. Among fresh Confervæ. 1-2400″

M. *hyalina.*—Ovate, colourless; active, and seems to leap or jump. In stale water in glass vessels. 1-6000″ to 1-2880″.

M. *gliscens.*—Ovate, colourless; motion gliding. In infusions of the stinging-nettle. 1-4500″.

M. *ovalis.*—Oval, colourless; motion tremulous. In water from the Anodonta Mollusca. 1-9600″.

M. *Mica.* —Oval, colourless; rotary and vacillating motion. In clear fresh-water. 1-1440″ to 1-1200″.

M. *Punctum.*—Egg-shaped; revolves on its longitudinal axis (xviii. 2); the lower figure exhibits one undergoing longitudinal division. In water with tannin. 1-1150″.

M. *Semen.*—Large, green, rather obovate, subcompressed; anterior end dilated, rounded; posterior attenuated; oral aperture (!) triquetral beneath the frontal portion; vibrates by numerous cilia (!). Length 1-48‴; motion vacillating, slow; a central, hyaline, subglobose gland; ovules large, green, ovate. It readily shows by diffluence the ova, gland, and bacillary spicula. Frontal end exhibits rugæ extending from the mouth. With decaying Sphagnum from marshes, Berlin. Surely this organism is not a Monad.

B.—Elongated Monads.

M. *cylindrica.* — Solitary, elongated, colourless; motion revolving. In salt water. 1-1150″.

M. *Okenii.*—Elongated, red; motion revolving, vibratory, social. In running water. 1-2300″.

M. *deses.*—Conical, green, solitary. In water from hills. 1-1200″.

M. *socialis.* — Conical, colourless, social. In water-butts. 1-700″.

M. *flavicans.* — Top-shaped; social; motion gliding. In ditch-water. 1-1720″.

M. *simplex.*—Spindle-shaped; colourless; motion gliding and rotary. In water of the Nile, and at Berlin. 1-1720″.

M. *inanis.*—Fusiform, colourless; motion vacillating. In stagnant and foul water. 1-3600″.

M. *scintillans*.—Fusiform, very active; motion vacillating. Amongst fresh-water Confervæ, &c. 1-6000″ to 1-4600″.

M. *Dunalii*.—Of a deep red colour; in vast numbers in the saltmarsh-water of the Mediterranean, to which they give a deep blood-colour. Discovered by M. Joly.

M. *prodigiosa*.—A very minute red Monad, so named by Ehrenberg from its surprisingly rapid development. It is this animalcule which has produced the blood-like spots occasionally appearing mysteriously on bread and other farinaceous substances, and which have ever been a cause of terror to the superstitious. Cohn asserts this organism to be a *Vibrio*, and not a *Monas*.

Being desirous of making this manual as complete as possible, the following species, described by M. Dujardin, are inserted; but it may be that some of them refer to Monads already characterized, but differently named.

M. *Lens* (XVIII. 10, 21).—Rounded or discoid; surface in appearance tubercular. 1-5200″ to 3-5200″. This species, one of the most frequent in animal or vegetable infusions, has been recognized by most of the ancient micrographers. It sends out obliquely a flagelliform filament, three, four, or even five times as long as the body, and mobile in all its length. Probably = M. *Guttula* (Ehr.).

M. *concava*.—Circular, concave on one side, thin in the centre, margin tumid; filament long, moveable throughout. In marsh water, Toulouse. 1-2080″.

M. *globulosa* (XVIII. 17).—Globular; form mostly constant; compressed at origin of filament; more globular than *M. Lens*, and its surface smooth. In sea-water at Cette, France. 1-2000″.

M. *elongata*. — Elongate; nodular, flexible, of variable form. 1-1200″. In marsh-water.

M. *attenuata* (XVIII. 19).—Ovoid, tapering at each extremity, nodular, vacuolæ large and distinct, as is also its filament. 1-1660″.

M. *oblonga*.—Ovoid, oblong, unequal, tubercular, hollowed by vacuolæ. 1-3600″. In vegetable infusions.

M. *nodosa*.—Oblong, irregular, nodose, tapering behind, truncate in front, filament arising from centre of truncate extremity. 1-2170″. In sea-water at Cette, France.

M. *gibbosa*.—Oblong, angular, irregularly distended and gibbose; filament springing mostly from an anterior constriction. Length 1-2000″. In infusions of gelatine.

M. *varians*.—Oblong, narrower in front, very soft, and variable in form. 1-650″ to 1-700″.

M. *intestinalis*.—Very elongated, form constantly changing, or one end rounded, the other tapering to terminate in a long filament; motion undulatory. 1-1600″. Found in the excrement of a newt (*Triton palmipes*). "I think this is one of the species of *Bodo*, described by Ehrenberg as met with in the intestines of frogs" (Duj.).

M. *fluida*.—Soft, semifluid; form variable, irregularly ovoid, sometimes constricted posteriorly, hollowed by large vacuoles. 1-2600″.

M. *constricta*.—Elongated, four or five times longer than broad; constricted, often much so at the centre. 1-1300″.

Perty has distinguished the following Monadiform beings by specific names:—

MONAS *curvata*.—A variety of *M. Lens*; tapering posteriorly.

M. *astasioides*.—Of variable form, often with one or two longitudinal lines, and a central vacuole. 1-1340″.

M. *irregularis*.—more or less globular, sometimes with capillary or angular processes; numerous dark internal molecules. 1-2000″ to 1-1250″. In ponds, Berne.

M. *pileatorum*. — Irregularly oval; pointed anteriorly; colourless; motor filament short, scarcely $1\frac{1}{2}$ times the length of the body; movement sluggish; nearly resembles M. *socialis*. 1-1400″.

M. *succisa*.—Oval; usually truncate, rarely pointed behind; colourless, transparent, with large vacuoles; filament twice the length of body; movement active and revolving. In water containing decomposing Anodonta, and foul pond-water. 1-1800″.

M. *cordata*. — Cordate seen on one side, on another oval and truncate; rounded anteriorly; hyaline or greyish from internal granules; swims tolerably fast with an oscillating motion, and seldom revolves; occurs singly and not often; filament extremely difficult to see, more than double the length of the body. 1140″ to 1080″. In freshwater ponds.

M. *urceolaris*.—Very small, urceolate, obliquely emarginate in front; colourless, transparent, with scarcely an appreciable differentiation of substance; filament indicated by the movement produced in the water at the anterior extremity; motion slow. 1-2640″. In brooks with *Hysginum pluvialis*.

M. *excavata*.—Round or oval, with a conspicuous speck in the anterior half; colourless, or occupied with amorphous brownish or greenish matter; filaments very fine, from 2 to 2½ times longer than the body. Motion active, in a straight line, and rarely revolving. 1-2100″ to 1-1200″. At Berne, in ponds among *Chara*.

M. *Rotulus*.—Elongated, cylindrical, of a homogeneous pale-green colour; filament apparently short; onward movement slow, although it revolves rapidly upon its long axis. 1-3000″ to 1-600″.

M. *Farcimen*.—Cylindrical, greenish, with red spots; flexible; onward movement and rotation rapid. 1-1800″ to 1-1080″.

M. *Hilla*.—Globular, or slightly elongate; of a dusky-green or brown colour. Larger specimens at times present a clear areola around coloured contents, with vacuoles in the latter; progression tolerably fast, turning more rapidly on the long axis. Length from 1-6000″ to 1-600″. The three species last named approach very closely to sporozoids of plants.

Fresenius has added the following species of *Monas* to the number already distinguished:—

MONAS *truncata*.—Hyaline, colourless; figure oval and rounded, truncate anteriorly, compressed; one larger and many smaller vacuoles often seen, the former near the middle. The truncate end supports two filaments, mostly on one side, equal to or rather longer than the body. Close beneath the anterior margin a small transverse corpuscle is mostly visible, of a faint green hue, and, some way beneath this, a small contractile vesicle. A side view shows a slight hollow on the under surface. Swims without revolving, and mostly in a straight course. 1-150 to 1-100 millim. in diam.

M. *consociata*.—Ovate, with one end tapering and trunk-like, and terminated by a filament more than double the length of the body. The proximal half of this filament often seems rigid, and only the distal or terminal half, which is difficult to detect without the use of iodine, motile. Body and its corpuscles colourless; among the latter is one prominent vacuole, not contractile. A multitude of these Monads occupied a transparent mucoid matter, which was not seen in motion. In still spring-water at Walldorf in June and July. It bears the nearest resemblance to *Cercomonas vorticellaris* (Perty). 1-100 to 1-75 millim.

M. *Oberhauserii*.—A carmine-coloured Monad found in the sulphureous spring at Frankfort, allied to *Monas Okenii* (Ehr.), and possibly the same as *Chromatium Weissii* (Perty). Cylindrical, rounded at each end, hyaline; faintly carmine-coloured, with a variable number of intensely crimson globules internally. Some specimens, however, have only a homogeneous red colour. Transverse fission frequently seen. It rotates rapidly, and advances with a tumbling sort of movement, no doubt by means of a filament; but this eludes observation. 1-83 to 1-46 millimètre.

M. *bipunctata*.—A much smaller species was found in the same glass with the preceding, having a red colour, an elongated oval figure, and a red point at each end. Longer specimens were noticed with four such red points, which might be in the act of fission. This form may be the same as the *Monas rosea* of Morren.

Genus UVELLA (XVIII. 3, 4).—Well characterized by the aggregating together occasionally of the individual Monads, so as to form a grape- or mulberry-like mass, and by their generally possessing two (?) hair-like filaments at the mouth. Like the Monads, says Ehrenberg, they are deficient of the projecting lips, visual organ, and tail, and have the mouth situated at the anterior extremity. They progress also in the direction of the longer axis of their body, and are capable of complete self-division. Of the several species, three are green, and the remainder colourless.

This genus belongs to the Aggregate Monadina of Dujardin, and is thus defined by him :—" animals globular or ovoid, having a single flagelliform filament, and living aggregated in spherical masses, freely moving about in the liquid." He further observes that isolated individuals are not at all distinguishable from simple Monads, that there is no good reason to suppose them to live alternately isolated and in masses—a circumstance therefore which cannot, according to Ehrenberg's statement, be employed to distinguish them from *Polytoma*.

Busk describes an early stage of development of *Volvox Sphærosira* as constituting "a species of the genus *Uvella*, or of *Syncrypta*, Ehrenberg" (*M. T.* vol. i. p. 40). Again, Cohn (on *Protococcus*, *Ray Soc.* 1853, p. 559) makes one of the multiform phases of development of *Protococcus pluvialis*, "when the zoospore is divided into thirty-two segments," equivalent to a *Uvella* or *Syncrypta*.

Perty, in his account of *Uvella virescens*, denies the existence of a common envelope, stating that when the water evaporates from around a specimen, the coverings of each individual corpuscle coalesce, and give rise to the appearance of a general investment around them. He adds, moreover, that at times the corpuscles are green, with a clear central stripe; at others, hyaline with a distinct green border, and some scattered specks; and at others, again, hyaline throughout.

Dujardin describes only two species, viz. *U. virescens*, and *U. rosacea* = *U. Glaucoma* (Ehr.). Perty contributes to the list *U. stigmatica*.

UVELLA *virescens* (*Volvox Uva*, M.).—Ovate, colour green, occurs in dense clusters amongst Confervæ and Lemnæ. 1-2000"; diam. of cluster 1-280."

U. *Chamæmorum*.—Smaller than the preceding one. In water-butts. 1-2880"; diam. of cluster 1-570".

U. *Uva*.—Has indistinct vesicles, and is very small. In stagnant water. 1-4800"; diam. of cluster 1-960".

U. *atomus* (*Monas atomus*, *M. Lens* et *Volvox socialis*, M.).—Voracious, with large vesicles. 1-6900" to 1-3400"; diam. of cluster 1-1150".

U. *Glaucoma* (*Volvox socialis*, M.).—Oval, inclining to conical; as it advances in age the posterior extremity is attenuated, and an elongated outline is assumed. Hyaline, with large vesicles, and two evident filaments: individuals loosely aggregated. In 1831, Ehrenberg first observed a vibration at its anterior part, and its reception of coloured food. In 1835, he discovered within the body of this minute creature some green Monads which it had swallowed. When fed on indigo, as many as twelve vesicles were filled, and it was sometimes seen to void little blue particles, like undigested matter, from its mouth. With a power of 800 diameters, a great number of small colourless granules, which he called ova, were discerned lying between the nutritive sacs. Fission both transverse and longitudinal (XVIII. 3, 4: figures magnified about 350 diameters). In water-butts. 1-2300" to 1-2350"; diam. of cluster 1-430".

U. *Bodo*.—Rounded in front, attenuated posteriorly; colour a beautiful green. In stagnant water. 1-4030" to 1-3450"; diam. of cluster 1-2350".

U. *stigmatica* (Perty).—Corpuscles of a uniform sea-green colour; each with a very fine red stigma. They are also somewhat broader than those of *U. virescens*, and have a more decidedly hyaline and apparently crenulated envelope. At Berne much rarer than *U.*

Genus MICROGLENA (XVIII. 6).—Characterized by the presence of a minute red eye-like speck at the anterior part of the body. In other respects the species resemble true Monads, having a very delicate filament, no projecting lips and tail, and swim in the direction of the long axis of the body. They multiply by complete self-division. Two species only are known—the one yellow, and the other green.

MICROGLENA *punctifera* (*Enchelys punctifera*, M.).—Yellowish, oval, or almost conical; posterior extremity acute. Eye-speck red with a blackish central spot. Among slimy-water plants. 1-620".

M. *monadina*.—Of a beautiful green;

form ovate, rounded equally at both extremities; red stigma; filament distinct, nearly as long as its body; motion vibrating, rotary on its long axis. (XVIII. 6. Three animalcules magnified, the first 800 diameters, exhibiting the internal organization as represented by Ehrenberg.) Among slimy-water plants (Hampstead and Finchley). 1-2300″ to 1-720″.

Genus CHLORASTER.—Solitary, without tail; mouth terminal; with a frontal ocellus or eye-speck; central portion of body with radiating rows of raised points (verrucæ). It is allied to the genera *Glenomorum* and *Phacelomonas*, but differs from the former by being solitary (not clustering), and by the greater number of filaments, and from *Phacelomonas* by having fewer filaments.

CHLORASTER *gyrans*.—Green; central part of body fusiform; extremities acute; central rays of puncta four. Filaments from 4 to 5″. 1-632″.

Genus PHACELOMONAS.—Filaments numerous (8–10) around the mouth. In other respects it resembles *Microglena*: it has the small red eye, the truncated mouth at the anterior extremity, but is without a tail. It swims in the direction of the longitudinal axis; and its self-division is simple and complete, but not constant in occurrence. Many vacuoles are seen within the body, but they have not been noticed to admit coloured food. This genus has not been figured by Ehrenberg.

PHACELOMONAS *Pulvisculus* (*Monas pulvisculus*, M.).—Figure oblong or slightly conical, attenuated posteriorly; of a beautiful green colour. Just previous to self-division, its body becomes cylindrical, then contracts at the centre; when dying it changes to a globular shape. In swimming, it turns quickly upon its longitudinal axis, without any vibration. In green puddles. 1-1152″.

Ph. Bodo (Stein) = *Uvella Bodo* (E.).

Genus GLENOMORUM (XVIII. 7).—Characterized by having a single red eye-speck, a truncated mouth, and two filaments; tail absent. Self-division simple and complete; their clustering is voluntary as occasion may require, and gives them the resemblance to a bunch of grapes. They swim in the direction of their long axis.

In this enumeration of the characters belonging to this genus, we are presented with an excellent illustration of the table (and one that exceedingly well explains its use), under which all the genera of the family Monadina are so arranged as to exemplify in what respects they are alike, and in what they differ from each other. For example (see Table, p. 487), *Glenomorum* closely resembles *Uvella*, but differs from it by the superaddition of the red stigma; it differs from *Monas* and *Microglena* in occasionally aggregating; from *Chilomonas*, in being deficient of the projecting lips; from *Bodo*, in not having the tail; from *Phacelomonas*, by the double proboscis; from *Doxococcus*, by swimming instead of rolling over or revolving in the water; and from *Polytoma*, by never appearing in clusters whilst undergoing self-division.

GLENOMORUM *tingens* (XVIII. 7).—Fusiform, three or four times longer than broad, of a beautiful green colour, with double, exceedingly delicate proboscis about half the length of its body. Internally are some small whitish vesicles, and the minute granules which give rise to the green colour. About the centre of the body is a large transparent colourless organ, the nucleus. The beautiful red eye-speck is placed about one-third from the anterior extremity of the body. These animalcules constitute a great portion of the green matter commonly seen on stagnant water, and discovered by Priestley. They appear to be nearly allied to *Cercaria viridis*, from which they differ only in magnitude and in the unalterable form of their bodies. Plentiful at Hampstead. Size 1-3600″ to 1-1700″.

Genus DOXOCOCCUS.—The Monads forming this genus differ from all others of the family Monadina by the singularity of their motion, which may be defined to be neither that of swimming nor of rotation, but a sort of rolling over and over. In other particulars they are like other Monads: they have the same unvarying form, and are destitute of the eye-speck, projecting lips, and tail; and self-division is simple and complete. Four species are known.

DOXOCOCCUS *Globulus.* — Subglobose or ovate; transparent as water; easily known by its tedious rolling motion; mouth not discerned. In salt water. 1-860″.

D. *ruber* (XVIII. 8).—Brick-red, globular, and opaque. Ehrenberg appears to doubt whether this animalcule belongs here (though its motion is very peculiar) or to the genus *Trachelomonas*; and he has not been able to satisfy himself of the existence of a lorica. Amongst Confervæ, &c. 1-1720″.

D. *Pulvisculus.*—Green, perfectly (?) globular, and opaque. Amongst Confervæ. Not exceeding 1-1280″.

D. *inequalis.* — Irregularly globular, transparent, and covered with green spots. Amongst Conferva. 1-2400″.

Genus CHILOMONAS (XVIII. 14, 18).—Characterized by the obliquity of the mouth with respect to the longitudinal axis of the body, which occasions a projection above the mouth of a lip-like appearance. Motion in the direction of the long axis of the body; form invariable; devoid both of eye-speck and tail. Whether the projecting lip is furnished with cilia, or with a double filament, Ehrenberg has not satisfactorily determined, except in the case of *C. Paramecium*, in which he states two filaments are to be clearly seen. On *C. destruens* there are a number of indistinct cilia. Self-division is simple and complete.

Dujardin's characters of this genus are, "Animals with an ovoid, oblong body, obliquely notched in front, with a very slender filament proceeding from the bottom of the notch. Movement from before backwards, on its centre. It is with doubt that I refer the Infusoria I thus name to the genus *Chilomonas* of Ehrenberg. The mode of insertion of the filament behind a projecting lip-like portion, approaches the animals to the *Euglenæ* and to certain Thecamonadina; but I cannot discover any trace of an integument, either contractile or resistant."

CHILOMONAS *Volvox.*—Ovate, attenuated and truncated anteriorly, transparent and colourless; projecting lip long; will feed on indigo. In stagnant water. 1-1440″.

C. *Paramecium* (XVIII. 14).—Oblong or ovate, wider at one end than at the other, keeled longitudinally; colour like that of dirty water. The contained granules have the reaction of starch. At the posterior end a clear nucleus with a reddish halo may be observed; and at the anterior is a reddish vesicle, probably contractile. It refuses coloured food. This animalcule is easily distinguished by its shape and peculiar lip-like process. With a power of about 240, numerous vesicles are visible, and with 380 the two filaments, which are half the length of the body, and proceed from a sinus in the wider end. It moves in the direction of its long axis, in a fluctuating or wavering manner. It sometimes clusters. In water wherein wheaten bread has been steeped. 1-1020″. The colourless variety of this species is enumerated by Perty as one of the many forms of his *Cryptomonas polymorpha*.

C. *destruens.*—Oblong, but variable in form, on account of its softness, nearly colourless or faint yellow. In salt and fresh water, and in the bodies of dead Rotatoria, e. g. *Anuræa foliacea* and *Monocerca Rattus.* 1-860″.

C. *granulosa* (Duj.) (XVIII. 18).—Colourless, oblong, larger anteriorly, almost invariable in form, although of gelatinous consistence; filled with granules which seem to project from its surface; filament very fine, arising from an oblique notch. 1-940″ to 1-850″.

C. *obliqua.*—Ovoid or pyriform, nodular, of variable form; the filament lateral. 1-2600″.

Genus BODO (XVIII. 9).—The caudal appendage at the posterior extremity of the animalcules is a decisive character of the genus; mouth terminal, furnished with a (single ?) filament; self-division simple and complete; eyespeck absent. They never constitute true or perfect clusters like some of the family Monadina, although, like *Uvella*, they occasionally aggregate. In *B. grandis*, several vacuoles have been observed, and (as also in *B. intestinalis*) a simple (perhaps double ?) filament. *B. didymus* has been known to divide transversely.

This genus *Bodo* partly comprehends the genera *Hexamita*, *Amphimonas*, and *Cercomonas* of Dujardin, which are, with others, introduced as addenda to this family Monadina. Dr. Burnett has made the following very correct and just remarks on this genus *Bodo* and its division into species:—

"The tailed Monads or Bodos are found in the intestines of the common house-fly or in those of the frog. Those from the fly, when first seen, resemble in shape a kernel of rye, and are about 1-6000th of an inch in breadth, and 1-2000th in length. Attached to the body is a delicate hair-like tail, four or five times its length. By the addition of water, the body enlarges by endosmosis, assuming a perfectly spherical shape after passing through all the intermediate ones, so that, when magnified by the highest power of Spenser's microscope, it is nearly one inch in diameter, permitting the most thorough and satisfactory study of their structure, which I find, after repeated observations, has no peculiarities except those belonging to cells. It is a closed cell sac, with a filiform caudate process, and capable of the actions of cell-membranes, viz. endosmosis and exosmosis. In the interior of this sac are found sometimes a few granules and sometimes a nucleus.

"In the Bodos of the frog, which are larger, I have seen distinctly, in some, a nucleus with a nucleolus, in others two nuclei, and in others still, four nuclei of equal size, thus showing that here the multiplication of cells takes place, as elsewhere, by segmentation of the nucleus.

"Apart from these characteristics, which are insufficient, the fact that I have sometimes met with them in the interior of epithelial cells, would be strongly presumptive of their cell origin from minute granules that pass through the cell-walls. The representatives of the genus *Bodo* therefore appear to be simple cells, each with a filiform appendage for locomotion, and which locomotion, therefore, can have *no* adaptive character.

"There are differences in them as they may be taken from different localities; but, because these particles are cells capable of much change by dilatation and contraction, these differences can never serve as the basis of species, which would also be true from the fact that, having no individuality of their own, there is necessarily no absence of type characteristics."

BODO *intestinalis* (XVIII. 9).—Almost conical, transparent, and colourless; tail of equal length with the body. Found in several living animals, such as frogs and toads. Amongst the watery mucus of the alimentary canal Ehrenberg has observed great numbers of these creatures, and remarks that the *Cercaria Gyrinus* of Müller (a different animalcule) might pass as a representation of this species, and that it was confounded by its discoverer with Spermatozoa. 1-1720".

B. *ranarum* (= *Cercomonas Ranarum*, Perty).—Body turgid, ventricles indistinct. In live frogs, with the preceding species, and with the *Bursaria ranarum*. 1-1440".

B. *viridis*.—Green, nearly globular; tail very short. Amongst Confervæ. 1-2400". Perty believes this species to be merely the young of *Euglena viridis*.

B. *socialis* (*Monas Lens*, M.).—Ovate or subglobose; tail often longer than the body; transparent and colourless. Clusters in a mulberry shape. Single forms are sometimes observed hopping. Common in stagnant water. 1-2970".

B. *vorticellaris* (= *Cercomonas*, Perty). — Body three times as long as it is broad; tail very short. In fresh water. 1-11200".

B. *didymus.*—Generally constricted about midway, tail short. 1-9600″.

B. *saltans.*—Very small; body with ample ventricles; tail short. This creature, most probably from its small size, has been mistaken for Müller's *Monas Termo*; but its brisk leaping movement will sufficiently distinguish it. 1-1200″.

B. *grandis.*—Oblong; vesicles ample; tail rigid, setaceous, affixed to the abdomen. In stagnant water. 1-864″. Lachmann states that an animal which was probably *Bodo grandis*, but might have been an *Astasia*, devoured *Vibrio* of two to four times its own length, and in this way acquired the most extraordinary forms; the mouth was close to the insertion of the flagellum.

B. *ostreæ* (Pritchard).—Globular; the anterior three-fourths occupied with vesicles, the rest hyaline; length of tail four times the diameter of body. This active creature was discovered in the liquor of an oyster, swimming freely among the ova (Sept. 1834). Diam. 1-2000″.

B. ? *Mastix* (Ehr.).—Obovate, turgid, smooth; terminal seta flexuose, acute, exceeding some two or three times the length of the body. Length 1-48‴ to 1-30‴, with the filament 1-20‴. The filament trails behind; motion slow, not leaping. This is the largest form of *Bodo* observed by Ehrenberg. Found about Sphagnum.

The following genera, named and described by Dujardin, are introduced into his family Monadina:—

Genus CYCLIDIUM (D.) (XXVI. 14, 15).—Body discoid, compressed, or lamelliform, scarcely variable; the filament thicker and more rigid near the base than that of *Monas*, the free extremity only being moved.

This genus is as yet but artificial, and indeed provisional; for true Monads perfectly developed may possess a filament with a thicker base, and, again, the constant outline of the body may be the consequence of the presence of an integument—in which case the animalcules in question would be referable to the family Thecamonadina. Movement slow and uniform.

It is to be regretted that Dujardin uses this generic name, as Ehrenberg previously employed it to designate certain ciliated animalcules which correspond but partially with those of Dujardin. Indeed this naturalist observes that "the genus *Cyclidium* (Ehr.) contains Monads also, and very probably some of those to which I have applied the same 'generic' name."

CYCLIDIUM *nodulosum* (Duj.).—Flattened, discoid, with rows of nodules and vacuoles; movement extremely slow. Length 1-5200″. In water from the Seine.

C. *abscissum* (Duj.) (XXVI. 15).—Membranous, lamelliform, truncated posteriorly; filament rigid; movement slow, regular. 1-1040″.

C. *crassum* (Duj.).—Oval, thick, and rounded; filament thickened at its base and rather sinuous; movements more active, zigzag. 1-1090″. Length of filament 1-600″.

C. *distortum* (Duj.) (XXVI. 14) (= *Spiromonas volubilis*, Perty).—Oval, flat, nodular, irregularly bent, with a tumid border. 1-1800″ to 1-800″.

"This species is perhaps only one phase of development of *Monas Lens*; it was found in Seine water kept during three months. When young it has the form of a disk, with a tumid and nodular margin; when, however, it has grown larger, it becomes twisted upon itself, and its movements irregular. Some individuals offered a certain affinity with the Trepomonads, which favours the opinion already advanced, that the majority of the Monadina are but modifications of one or of several types."

Genus CERCOMONAS (D.) (XVIII. 11, 12, 20, 22, 23).—Body rounded or discoid, tubercular, with a posterior variable process in the form of a tail, of greater or less length and fineness.

The Cercomonads differ from the Monads by the posterior prolongation, which serves, by the adhesion of its extremity, as a point of support: it occurs either as a very fine thread or contracted into a small tubercle; it is sometimes nearly as fine as the anterior filament, and susceptible of an undulatory motion. I have not unfrequently witnessed the transition of Monads to the condition of Cercomonads.

We may conclude that many of the animalcules described in the genus *Bodo* (Ehr.) are examples of this genus (*Cercomonas*, Duj.), although sufficiently marked characters are wanting in order to discover specific identity.

CERCOMONAS *detracta*. — Discoid or oblong, granular, with a thick tail. 1-7000″ to 1-2300″.

C. *crassicauda*. — Elongated, nodular, flexible, or variable in form, more or less contracted posteriorly into a tail. 1-3400″ to 1-2600″.

C. *viridis*.—Ovoid, oblong, tubercular, green, prolonged posteriorly into a tail of varying tenuity, or into a rounded lobe or spathulate expansion. 1-1500″. Perty believes this to be no other than an early stage of development of *Euglena viridis*.

C. *lacryma*.—Globular, unequal, elongated posteriorly as a long flexuose tail. Length of body 1-5200″ to 1-3000″; of tail 1-2600″; of filament 1-750″.

C. *acuminata* (XVIII. 20).—Globular or ovoid, contracted posteriorly into a short tail, terminated by a very fine filament. 1-2600″ to 1-1900″.

C. *Globulus* (XVIII. 23). — Globular, with a filament at each extremity double its length, the anterior one more actively moved. Length 1-2600″. In marsh-water.

C. *longicauda* (XVIII. 22).—Fusiform, flexible, terminated posteriorly by a long and very slender flexuose filament. 1-1800″.

C. *fusiformis*.—Dilated at centre, constricted in front, and prolonged behind into a long delicate tail. Length of body 1-1900″.

C. *cylindrica*. — Elongated, cylindrical, constricted posteriorly, terminated by a long, straight, and very thin tail. Length of body 1-2600″; of tail the same.

C. *truncata* (XVIII. 12 *a*, *b*). — Contracted posteriorly; truncate in front, with a filament springing from each of the truncated angles; the posterior angle extended more or less into a lobe. 1-3000″ to 1-1900″.

C. *lobata* (XVIII. 11 *a*, *b*).—Variable in form, tubercular, sending out a flagelliform filament from the end of an anterior lobe, and emitting also one or two other lobes. 1-3250″ to 2-3250″.

It is right to mention that Dujardin has noted the occurrence of several of the above Cercomonads in organic infusions, in conjunction particularly with *Monas Lens*, and that he inclines to the idea that these differently-named Infusoria are merely different conditions of the same animalcule.

Perty adds the following species:—

C. *intestinalis*.—Has a posterior vibrating filament, and probably an anterior one also. Internal molecules very fine; body transparent; posterior filament about three times the length of the body. Is common in the intestine of the frog, and is in part equivalent to *Bodo intestinalis* (E.). 1-3000″.

C. *curvata*.—Cylindrical, curved, with an anterior and a posterior filament. In some specimens apparently two filaments occurred in front. 1-2400″. Very active: occurs among the ova of the frog (*Rana temporaria*).

C. *vorticellaris*=*Bodo socialis* and *B. vorticellaris* (E.).

C. *Ranarum*=*Bodo ranarum* ? (E.).—Colourless, soft, more or less conical; tapering or rounded behind, but without posterior filament. In water with Mollusca, and in the intestine of frogs.

C. *clavata*. — Colourless or greyish, thickened anteriorly, tapering posteriorly, club-shaped; motion rather quick; periphery clearer than the centre. 1-570″.

C. *Falcula*.—Colourless, transparent, compressed and curved (?), much widened in front, truncate and emarginate; posterior portion tapering to a blunt apex; movements sluggish. 1-720″.

Genus AMPHIMONAS (Duj.) (XVIII. 13).—Animals of variable, irregular form, having at least two filaments, of which one is either in front, and the other on one side, owing to a constriction of the body, or both are lateral, and accompanied or not with a caudiform prolongation. The leaping movements of *A. caudata* are remarkable, and the variability in form is characteristic of each species.

AMPHIMONAS *dispar* (XVIII. 13 *a*, *b*).—Oblong, of very variable form, one or other end constricted, or prolonged laterally into two filaments. 1-3500″ to 1-2900″. Movement active, jerking.

A. *caudata*.—Of very variable form, mostly depressed, tubercular, convex on one side, angular on the other, with a filament proceeding from the summit of each angle. 1-2180″ to 1-1300″.

"This species seems to me," says Dujardin, "to be allied to the *Bodo saltans* of Ehrenberg. In every example, I saw two flagelliform filaments, one from the anterior, the other from the lateral angle; a caudiform prolongation, obtuse or drawn out as a third filament, often adhered to the slide."

A. *brachiata*.—Under this name is indicated an animalcule of the family Monadina, which Dujardin only once met with, of an ovoid or pyriform shape, filled with granules, and giving off from its narrower anterior end a simple flexuose filament, together with a variable dilated lobe emitting two other filaments having an undulatory motion. The animal progressed by leaps, revolving at the same time.

A. *exilis* (Perty).—Colour soft grey; figure wedge-shaped, oftentimes emarginate anteriorly; filaments two, twice the length of the body, colourless; motion oscillating. 1-2000″.

Genus TREPOMONAS (D.) (XVIII. 16 & 27).—Body compressed, thicker and more rounded posteriorly; its anterior extremity presents two thin lobes, bent to one side and each terminated by a flagelliform filament, which produce an active whirling and jerking movement.

"The examples of this genus are very common in all collections of marsh-water containing decomposing plants, but are most difficult to determine, owing to the irregularity of their form and the rapidity of their movements. I have rather glimpsed than certainly detected their flagelliform filaments, and have in vain attempted accurately to delineate them."

TREPOMONAS *agilis* (XVIII. 16, 27).—Body granular, unequal. 1-1300″.

Genus HEXAMITA (D.) (XXVI. 1).—Animals with an oblong body rounded in front, constricted and bifid or notched behind. Two to four filaments extend from the anterior border; and the two posterior lobes are prolonged as two flexuose filaments.

This genus, characterized by the number of its motor filaments, appears sufficiently distinct from the preceding. Its species occur in decomposing marsh-water and in the intestine of Batrachians, but not in artificial infusions.

HEXAMITA *nodulosa* (XXVI. 1).—Oblong, with three or four longitudinal rows of nodules, the two lateral of which are extended into tapering slender lobes, each terminated by a filament; movement vacillating. 1-1300″ to 1-1500″.

H. *inflata*.—Oval oblong, rendered almost quadrangular by the processes which give origin to the filaments. 1-600″ to 1-1300″.

H. *intestinalis*.—Fusiform, prolonged into a bifid tail. Very common in the abdominal cavity of the Batrachia (frogs and newts). It moves in a straight line, oscillating from side to side.

Genus HETEROMITA (D.) (XXVI. 5; XVIII. 26).—Body globular, ovoid, or oblong, with two filaments extending from the same point in front —one slender, undulating, and producing an onward movement, the other thicker, stretching posteriorly, and free, or contracting adhesion with the glass slide along which it moves, so as to cause a sudden movement backwards.

"The several sections of the Monadina, together with the Thecamonadina and the Euglenæ, contain Infusoria possessing two filaments, by one of which they progress, by the other adhere for support to any solid body, and produce a sudden movement backwards by its contraction. To prevent confounding specimens of these several families, the same distinctions which mark the

Monadina generally, must be found in order to constitute the Heteromita members of that family,—such as the absence of integument, the gelatinous appearance of the entire mass admitting of agglutination to other objects, and the drawing out of its substance into filamentous processes, together with the existence of certain corpuscles, which can only have penetrated the interior as a consequence of the formation of vacuoles at the surface" (Duj.).

HETEROMITA *ovata* (XXVI. 5).—Ovate, narrower anteriorly, containing vacuoles, granules, and Naviculæ. 1-1050" to 1-1150".

This is probably the *Bodo grandis* of Ehrenberg. His other Bodos are not *Heteromitæ*, but imperfectly-observed Cercomonads or Amphimonads.

H. *Granulum*.—Globular, surface granular. 1-2600". In rather putrid sea-water.

H. *angusta*.—Narrow, lanceolate, slightly bent, tapering at each end, with a flagelliform and a second filament from the same point anteriorly, erect at the base, but floating freely the rest of its length. 1-1050".

This is a doubtful species; it is of the shape of a lanceolate leaf, with a mid-rib or longitudinal fold.

The following species are from Perty's work:—

H. *pusilla*.—Colourless, very delicate, cylindrical or Euglena-like in figure, constricted at the centre, often emarginate posteriorly; filaments 2 to 2½ times longer than the body; movements inactive, oscillating; few fine granules internally. 1-3000" to 1-2160". Allied to, but smaller than, *H. angusta*, and like *Amphimonas dispar*, in which, however, both filaments are equal. In ponds at Thun.

H. *exigua*.—Oval or spheroidal, colourless; filaments about three times the length of the body; movements inactive. 1-7000" to 1-4800". In turf-hollows on the Bernese Alps.

Genus TRICHOMONAS (D.) (XVIII. 28).—Body ovoid or globular, capable of being drawn out when adherent, and in this way presenting sometimes a caudal prolongation. The anterior flagelliform filament is accompanied with a group of vibratile cilia.

TRICHOMONAS *vaginalis*.—Gelatinous, nodular, unequal, hollowed by vacuoles, often adhering to other bodies; movement oscillating. 1-2600".

T. *Limacis*.—Ovoid, smooth, pointed at each end, and terminating in front by a flagelliform filament, from the base of which a row of vibratile cilia is directed backwards; progressive movement active, the animalcule at the same time turning on its axis. 1-1730". Found in the intestine of *Limax agrestis*.

T. Batrachiorum (Perty) (XVIII. 28*a, b, c, d*).—Widely oval, at times slightly emarginate in front, mostly with a keel along the back, colourless, and 8 to 10 cilia on the left side; resembles *T. Limacis*, but is more finely granular. 1-2400" to 1-1300".

Genus ANTHOPHYSA (D.) (XXVI. 2).—Animals ovoid or pyriform, furnished with a single flagelliform filament, and collected in clusters at the extremities of a branching stem, or polypidom, secreted by themselves; clusters when detached resembling those of *Uvella*.

The tree-like polypary is brown at the base, but clearer and even diaphanous at the termination of the branches, which appear nodular. The groups of animalcules are easily detached from the stem, and then commence a rotatory movement by the action of the filaments of each individual in the group. Detached solitary animalcules move like the common monads with a single filament. The branching support, at first soft and gelatinous, becomes by degrees more consistent, brown, and of a horny character, appearing to partake no longer of the vitality of the animalcules.

A. Mülleri was erroneously placed by Ehrenberg in the genus *Epistylis*, among the Vorticellina, and called *E. vegetans*.

The delicate branched fibre or stem has been considered a microscopic fungus, and been named by Kützing *Stereonema*. Upon this view, the monadiform beings crowning the summits of the branches have been conceived to represent the spores. This opinion has been carefully investigated and rejected by Cohn (*Entwick. d. mikroskop. Algen u. Pilze*, pp. 114–115), who confirms Dujardin's description, and regards it as a stalked *Uvella*.

ANTHOPHYSA *Mülleri*. — With the characters described.

A. *solitaria* (Bory).—A species was described under this name by Bory de St. Vincent, and is again brought to notice by Fresenius, who met with it in some standing water with *Salvinia*. The stem is simple (not branched), and has a clear outline to its extremity. Its length is from 1-25 to 1-8 millim.; and in water it has a clear brownish-green colour. Its apex is surmounted by the monadiform beings, looking like so many short hyaline fibres. Each monad contains a comparatively large non-contractile vacuole having a red refraction, and is furnished with a filament at its free extremity. Length of monads 1-100 to 1-75 millim. The fixed stem can bend itself from side to side. In one specimen a contractile vesicle was seen in one of the monads. This organism appears to be precisely the same as the *Epistylis Botrytis* (Ehr.).

Genus PERONIUM (Cohn), represented by one species.

PERONIUM *aciculare* has been newly described by Cohn (*Entwick.* &c. p. 158) as a form allied to *Anthophysa*. It is parasitic on the spores of *Pilularia*, and consists of a delicate colourless fibre surmounted by a globular head, which resolves itself into numerous swarm-cells of a monadiform character.

The two next genera are named by Werneck (*Monatsbericht der Berlin. Akad.* 1841, p. 377), and thus briefly described:—

Genus ANCYRIUM = Enterodelous Bodos (*i. e.*, according to the nomenclature of Ehrenberg, Bodos furnished with an intestinal tube) with a moveable setaceous foot.

The existence of an alimentary tube (so supposed) removes the *Bodo grandis* and the six allied species (*i. e.* the genus *Ancyrium*) far above the Monadina of Ehrenberg, whilst the possession of the setaceous foot also indicates a higher organization.

Genus ERETES = Loricated Phacelomonads.

The following are the new genera of Monadina instituted by Perty:—

Genus TETRAMITUS (Perty) (XIX. 3).—Figure conical, tapering posteriorly, and having four vibratory filaments in front. *Hexamita* differs in having in addition two posterior filaments.

TETRAMITUS *descissus* (XIX. 3). — Wedge-shaped, curved, truncate anteriorly, and colourless or pale grey. Surface marked by cross-lines. Movements tolerably active and oscillating. Filaments nearly twice the length of the body. 1-1860″.

T. *rostratus*.—Colourless, with an anterior border; one side elongated as a prominent angle or beak. Smallest specimens 1-7000″, the largest 1-1080″ in length. Bern. In stale pond-water. Fresenius describes it as rather pyriform, truncate anteriorly, with a short trunk-like process from one side; elongated and pointed behind. A vesicle (contractile?) at the anterior extremity.

Genus MALLOMONAS (Perty) (XIX. 4–6).—Body oval, elliptic, or discoïd, with brown or greenish contents. Surface covered with long motionless hairs. A single filament anteriorly, double the length of the body.

MALLOMONAS *Plösslii* (XIX. 4–6) (formerly described as *M. acaroides*).—Mostly oval; the smaller end anterior; rarely elliptic or discoid; the periphery apparently crenulated—an appearance probably due to the points of insertion of the hairs; these are commonly longer on the posterior half. Contents sometimes seen longitudinally or transversely divided. Movements rather rapid, but rarely attended by a rotation of the body. In one example the hairs seemed terminated by a knob. It is not improbable that *Pantotrichum Enchelys* (E.) is also a member of this genus. 1-1440″ to 1-960″. Bern. In ponds. — A variety (*M. epilis*) occurs, having the hairs short or actually absent, although covered with little nodules which serve as bases for hairs. Fresenius has noticed this organism. He adds, the ends are often pointed. The hairs or bristles are long, and tolerably numerous—as many as 30 have been counted, placed at all parts of the periphery. The anterior setiform hairs are most concerned in locomotion; those placed laterally either lie along the sides pretty closely, or stand out at a greater or less distance, and appear concerned chiefly in changing the position. The two most in advance seem to have the character of feelers. A clear vacuole was sometimes seen in the middle of the dusky-green contents. A few small, contractile, optically red specks have also been observed. 1-720‴ to 1-444‴. Fresenius considers it ought to be removed from the Monadina; and Perty is himself unable to decide whether this genus is referable to the Ciliata or to the Phytozoa.

Genus PLEUROMONAS (Perty) (XVIII. 25).—Body reniform, extremely delicate, small, colourless; filament extended from the concave side of the body, and three times its length.

PLEUROMONAS *jaculans* = *Chilomonas obliqua* (?) (Duj.) (XVIII. 25).—Colourless, transparent, with a few small molecules. Movements eccentric, hither and thither in a jerking and leaping manner, followed by intervals of rest. Very young specimens are round. 1-6000″ to 1-3160″. Bern. In stale water and infusions of Lycopodium seeds.

Genus SPIROMONAS (Perty) (XVIII. 24).—Body leaf-like, compressed, rounded at both ends, and rolled spirally on itself longitudinally.

SPIROMONAS *volubilis* = *Cyclidium distortum* (Duj.).—Colourless, transparent, smooth, very delicate. Revolves rapidly on its long axis. Not nodular on the margin, like the *Cyclidium distortum* of Dujardin, but is probably (as Dujardin believes the latter to be) merely a phase of *Monas Lens*. 1-1800″ to 1-1300″. Bern. In foul water.

Genus MENOIDIUM (Perty) (XIX. 2).—Body small, crescentic, thicker on the outer or convex margin; containing internally small molecules and vesicles; colourless, or occupied with a little chlorophyll.

MENOIDIUM *pellucidum* (XIX. 2). — Recalls by its figure a little *Closterium lunula*; not rounded, but flattened like a sickle. Movement tolerably rapid, jerking and revolving. 1-670″ to 1-430″.

Genus CHROMATIUM (Perty) (XIX. 1).—Body extremely small, red, brown, violet, or green in colour, containing in the mature condition some internal vesicles. A motor filament at the anterior extremity (?). Multiplication by transverse fission. To this genus Perty would refer the greater part of the Monads described by Ehrenberg which possess a brilliant colour; and he is in doubt whether they are not all rather referable to the genus *Bacterium*, as well as the next genus named, *i. e. Acariæum*. However, he at present retains *Chromatium* and *Acariæum* among the Monadina, and establishes two species of the former.

CHROMATIUM *Weissii* (XIX. 1). — Of a violet or brownish colour, rounded and truncate both before and behind; vesicles within sharply defined. The *Monas Okenii* of Weisse is very closely allied, but still more minute. It progresses and revolves rather rapidly, taking a straight course. The vesicles are not present in very young specimens: they first show themselves as dark points, and afterwards assume the vesicular form. Perty cannot discover the filament described by Ehrenberg in *Monas Okenii*. Eichwald says of this species that it swims backwards or forwards indifferently,—a circumstance adverse to the existence of a filament at all. 1-4800″ to 1-2400″. Occurs among Characeæ.

C. *violescens*.—Globular or elliptical, transparent, and of a very pale violet colour. It appears closely related to, although not identical with, *Monas vinosa* (E.). A filament could not be detected, nor any internal organs. At Bern, with Chara. 1-14,000″ to 1-3000″. These coloured organisms form a colouring layer on the mud at the bottom of ponds, &c. The several species mentioned by authors referable to the genus *Chromatium* are—*Monas rosea*, Morren; *Monas Okenii*, Weisse; *Monas vinosa*, *M. erubescens*, *M. ochracea*, and probably *M. prodigiosa* and *M. gliscens* of Ehrenberg's category.

Genus ACARLÆUM.—Extremely minute, globular or elliptical; perfectly transparent, without a trace of either external or internal organs.

ACARLÆUM *Crepusculum* = *Monas Crepusculum* (E.).—They swim rapidly past each other, yet have nothing in their movements in common with those of the Monads, but much rather with those of the *Bacterium Termo*.

Genus RHABDOMONAS (Fresenius).

RHABDOMONAS *incurva*.—Stout, elongated and cylindrical, slightly falcate; anterior extremity rather the thicker; three prominent longitudinal ridges; green vesicles or granules occupy the anterior half of the body; progresses in a straight line, with a rotary or semi-rotary motion on its long axis; filament 1½ the length of the body. 1-60 to 1-50 millim. In stagnant water with Confervæ, &c.

Genus GRYMÆA (Fresenius).

GRYMÆA *vacillans*.—Colourless, hyaline, compressed; when seen on its flat side its outline is circular, but on the narrow side, pyriform, the posterior compressed portion gradually thickening towards the thicker front part. Advances with the thick end foremost, slowly revolving on its long axis, with an oscillating motion. Filament revealed by iodine. In standing water with Vallisneria in the Botanic Gardens. It is, not unlikely, the same being as *Monas urceolaris* (Perty).

FAMILY II.—HYDROMORINA.

Characters.—Anenterous Polygastrica without appendages; body uniform, like that of the Monads, but, by reason of the spontaneous fission being imperfect, developed into a moniliform mass or polypary; lorica absent. Individuals are at periods set free, which commence the same cycle of compound development as the parent beings to which they originally belonged (Ehr.).

The genera belonging to this family are *Polytoma* and *Spondylomorum*. *Polytoma* was described by Ehrenberg in the family Monadina; but the subsequent discovery of the genus *Spondylomorum*, having the same general characters, and differing like it from the other monads, led him to create this new family Hydromorina to embrace the two.

Perty has also recognized the propriety of detaching those Monadina which, by the act of self-fission continuing incomplete, live together in compound masses, and to designate them has invented the term "*Monadina Familiaria*," equivalent in English to "*gregarious* or aggregated Monadina." Under this group, however, he has placed two other genera, which Ehrenberg has let remain, somewhat unaccountably, among those Monadina living in an isolated or free state. These other members of the Hydromorina or Aggregated Monads are, *Uvella* and *Anthophysa*. Schneider (*A. N. H.* 1854, xiv. 326) observes on the near alliance of *Polytoma* to *Chlorogonium euchlorum*. It would seem that Cohn fails to find any truly distinctive characters between

Polytoma and *Chlamydomonas*; for he proposes (*Entwick.* p. 140) to apply to *P. Uvella* the name of *Chl. hyalina.*

Genus POLYTOMA (XVIII. 5; XX. 1–14).—Mouth terminal, truncate, surmounted by a double flagelliform filament situated as in *Monas* and *Uvella*; eye and tail wanting. It will not imbibe colouring matter. A large contractile vesicle and the trace of a nucleus are sometimes observable. Self-division occurs both transversely and longitudinally, and produces a berry-like cluster of many individuals. As the young increase in size, the parent body assumes a decussated or wrinkled appearance, like a mulberry, and in this manner indicates its approaching self-division into *many sections* (as the name *Polytoma* denotes), or numerous individuals. In swimming, the filaments are extended in advance. In putting forward the self-division of *Polytoma* as a peculiar feature, Cohn says that Ehrenberg has mistaken a transitional for a permanent condition. It was known to Müller and Wrisberg.

POLYTOMA *Uvella* (*Monas Uva*, M.).—Colourless, of an oval or oblong form; extremities equally obtuse. It is often abundant in water where animal matters are in solution, upon which it appears to be nourished; generally in company with species of *Vibrio* and *Spirillum*, and sometimes with *Uvella Uva* and *U. Atomus.*

Group 5 shows two isolated individuals; another about to divide longitudinally; a cluster of eight united within a common envelope; another cluster, of which the common envelope has disappeared prior to the separation of the individual Monads, and in the two isolated beings the double filament is very distinct. 1-200″ to 1-90″; diam. of clusters 1-380″.

Schneider (Part I. p. 136) has closely examined this species (xx. 1–14). The hyaline investing membrane, he says, can be distinctly displayed by using chromic acid, or solution of iodine in chloride of zinc. A globular nucleus lies near the centre, with a narrow reddish halo around it: dilute acids render this more distinct (xx. 2). At the anterior extremity are two reddish vesicles, which are contractile; and other non-contractile reddish ones are scattered in the interior. The creature "rotates upon its axis; and this, again, describes circular vibrations upon a central point." Self-division takes place at first into two (xx. 3), then into four (xx. 9), and, under favourable conditions, into eight segments, each of which acquires its filaments, and moves about within the envelope of the parent with the rest until set free by its rupture. Under certain circumstances the individuals pass to a state of rest (xx. 7), and then do not undergo fission or any other change, but remain in a torpid condition. In assuming this state the filaments contract gradually, and at length seem to be withdrawn completely within the contained substance of the encysted being. The internal granules of *Polytoma* are, according to Schneider, composed of starch, and are convertible into a blue or a green colouring matter.

Perty has distinguished three additional species, viz.—

POLYTOMA *Uva.*—Divides into as many as ten segments. The mode of fission much resembles that of *Chlamydomonas*, but differs in exhibiting active movements during the process, instead of the state of rest seen in the latter. The corpuscles are usually oval, and hyaline; rarely yellow or brown; filled with larger or smaller vesicles, and in old specimens with black molecules. Self-division proceeds rapidly. Movements darting and revolving. An enveloping cyst has been noticed in some examples. Uncommon in fresh, but frequent in water holding animal decomposing matters in solution. Two varieties are distinguishable: viz.—Var. *a unifilis*, having only one filament, resembling *Trachelius globulifer* (E.), and very probably identical with *Monas punctum*; Var. *b. rostrata* seu *hysginoides*, of a feeble yellow colour, with a prominent cyst-wall, within which it is contracted and deprived of its filaments. It does not break up on drying, but can continue several weeks without change. [This is evidently not even a variety in the proper sense, but simply an encysted *Polytoma.*]

P. *ocellata.*—Oval; filled with vesicles, like *P. Uva*, except that it has a clear-red stigma at the centre. Motion languid. Self-fission produces few new beings; and these lie parallel to each other. Has the dimensions of *P. Uva.* Found in decomposing infusions. Schneider describes a peculiar mode of fission seen at times in *P. Uvella,* in which the segments lie parallel to each other: very probably this supposed species, *P. ocellatum,* is nothing more than that phase of *P. Uvella.* The reddish vesicle is worthless as a specific character.

P. ? *virens.*—Greenish or actually green, surrounded by a hyaline cyst. Seen only in process of fission, when each segment had its own filament. These organisms were for some seconds at rest, and soon afterwards moved here and there with activity. Very probably this being is only a sporule, and seems nearly akin to *Chlamydomonas.*

Genus SPONDYLOMORUM.—Individuals furnished with a dorsal ocellus, are destitute of a tail, and, in consequence of their imperfect self-division, develope a compound body (polypary) resembling a whorl or cluster of berries.

SPONDYLOMORUM *quaternarium.* — A group of four alternating corpuscles, of which the terminal one is the most slender; colour green; filaments four to five. Length of polypary 1-576", of each individual 1-1728".

FAMILY III.—CRYPTOMONADINA.

(XVIII. 29–34; XIX. 7–16 and 20–31; XXVI. 6, 8, 9, 10.)

THE Cryptomonadina (*vide* General History, p. 140) are Monadina enveloped within a distinct gelatinous, membranous, or hard induvium, forming a shell-like covering or lorica. According to Ehrenberg, the lorica sometimes resembles an open shield (*scutellum*), at others a closed box or pitcher (*urceolus*). The construction of the lorica, however, as a scutellum, open on one side, is denied by every recent writer; and in all cases it would appear to completely enclose the contents. Two delicate, filiform, and generally retractile filaments, capable of being put into very powerful whirling and lashing motion, are clearly perceptible in all the genera, excepting, perhaps, the genus *Lagenella*; and even in this, Dr. Werneck believed he had discerned them. Six or seven species exhibit internal vesicles; and in two genera a coloured spot is present at the fore part of the body. From the position of this speck the dorsal line may be readily conceived, and a right and left side described. Self-division, when it occurs, is simple and complete. "It is possible," says Ehrenberg, "that the fossil animalcules discovered in the flint of chalk and porphyritic formations, and named by me *Pyxidicula* (see Plate XVII. upper figures), belong to the genus *Trachelomonas.*"

Lachmann (*op. cit.* p. 219) asserts that in all transparent Monadina and Cryptomonadina a contractile vesicle exists, and that even in the more opake *Chilomonas Paramecium* and *Cryptomonas ovata* he was able to observe its contractions. Mr. Carter confirms this statement.

The genera were thus tabulated by Ehrenberg:—

Eye-speck absent.	Lorica obtuse and smooth...	Form short; self-division longitudinal or wanting	Cryptomonas.
		Form long and tortuous; self-division transverse	Ophidomonas.
	Lorica pointed anteriorly		Prorocentrum.
Eye-speck present.	Lorica with a neck and narrow orifice		Lagenella.
	Lorica with orifice, but no neck.	Lorica an open shield (*scutellum*).	Cryptoglena.
		Lorica a closed box (*urceolus*).	Trachelomonas.

The members of this family are readily recognized by the stiffness or inflexibility they display while swimming or when brought into contact with other bodies. The lorica of *Prorocentrum* and *Lagenella* is at once perceived to be a distinct covering. When any doubt, however, exists upon this point, a slight degree of pressure upon the specimens placed in an aquatic live-box, or between two slips of polished glass, will easily determine it. The lorica of *Trachelomonas* Ehrenberg affirmed to be silicious, and indestructible by fire. Dujardin has a parallel family he names Thecamonadina, consisting of eight genera. These, however, are not the same as the genera of Cryptomonadina of Ehrenberg, of which only two are retained, viz. *Trachelomonas* and *Cryptomonas*. In the last-named genus are included *Cryptoglena* and *Lagenella*, which Dujardin considers have no claim to generic distinction. *Prorodon* may, he thinks, be the same as his genus *Oxyrrhis*; and under the head of *Trachelomonas* he unites *Chætotyphla* and *Chætoglena*, numbered among the Peridiniæa in the classification of Ehrenberg. A new genus, *Phacus*, is constructed by the same author, to receive those green organisms having a rigid inflexible tunic, which Ehrenberg placed with the flexible and protean *Euglenæ*. Another group, styled *Diselmis*, includes many of the Chlamidomonads of Ehrenberg. Besides these, three other new genera, viz. *Crumenula*, *Plœotia*, and *Anisonema*, enter into this family Thecamonadina, and are described as addenda to the Cryptomonadina of Ehrenberg. The accompanying tabular view represents at a glance the distribution adopted by Dujardin:—

THECAMONADINA.

Body ovoid or globular	Integument hard and brittle	1. Trachelomonas.
	Integument membranous	2. Cryptomonas.
Body flattened or leaf-like, with a single filament	With a caudal prolongation	3. Phacus.
	Without such	4. Crumenula.
The two filaments equal		5. Diselmis.
One flagelliform, one trailing	Body prismatic or navicular	6. Plœotia.
	Body ovoid, in form of a grape-seed, with two filaments	7. Anisonema.
With several filaments	Body prolonged anteriorly into a point	8. Oxyrrhis.

Perty borrows from both Ehrenberg and Dujardin, by instituting two families, Cryptomonadina and Thecamonadina, and distributes the several species in another fashion, under new generic names. The distinctive characters of the two families are thus set forth:—

Cryptomonadina.—The surface of the body more or less hardened, but inseparable from the contained substance as a distinct testa.

Thecamonadina.—Possess a distinct red stigma, and, though naked at first, acquire an apparently separable, brittle, silicious shell or testa, having an opening at its fore part for the protrusion of the filaments. In the act of fission the beings (which may or may not entirely occupy the shell) divide into two or four new individuals.

The Cryptomonadina comprise the genera *Cryptomonas*, *Phacotus*, *Anisonema*, *Phacus*, and *Lepocinclis*; and the Thecamonadina include *Chætotyphla*, *Trypemonas*, and *Chonemonas*.

Cohn (Siebold's *Zeitschr*. 1853, Band iv. pp. 275–277) sanctions this subdivision of the Cryptomonadina into two families; for he remarks that *Crypto-*

monas and *Cryptoglena*, and other forms, have a hard integument or lorica (Panzer) inseparable from the subjacent mass, whilst *Trachelomonas*, *Lagenella*, and *Chætoglena* possess a distinct separable capsule or cyst, within which, at a certain period, the contained *Euglena*-like being can contort itself and revolve at pleasure. Moreover, Cohn's opinion is that these capsuled forms should be detached from the Monadina or Cryptomonadina, and placed with the Euglenæ. In this opinion we entirely coincide, and would regard the capsuled monadiform beings as simply encysted *Euglenæ*. Indeed, the present state of knowledge, especially respecting the process of encysting, irresistibly leads to the conclusion that this entire family Cryptomonadina of Ehrenberg must be broken up, and its several forms distributed among various groups of animalcules and plants, as representing their encysted phase or condition.

Fresenius adds a new genus to the Cryptomonadina, which he calls *Drepanomonas*.

Genus CRYPTOMONAS (XVIII. 29).—Coloured stigma absent; lorica obtuse, or not attenuated anteriorly; body short, but not filiform; self-division, if any, longitudinal; flagelliform filament very fine.

Dujardin writes, "In this genus *Cryptomonas* I comprise all Thecamonadina with a single filament, and with a lorica neither hard nor brittle, and whose body is not depressed (compressed) like that of *Phacus* or of *Crumenula*; and I moreover do not doubt that when these Infusoria are better known, other genera may be distinguished by their more or less globular form, by the consistence of their envelope, and especially by their mode of existence. I already indicate as subgenera, *Lagenella* with an elongated lorica, and *Tetrabæna*, the species of which are united in groups of four, not enclosed, however, within a common envelope. As to the character supplied by the presence of a red speck in some individuals, assumed by Ehrenberg to be an eye, I cannot discover in it a generic distinction; nor am I able to admit the existence of a lorica open on one side (below) like a shield (carapace). On the contrary, I have always observed the lorica to be closed and entire, though sometimes compressed on one side, adapting itself to the living mass enclosed. The covering in every case is evidently larger than the contained mass, a diaphanous space intervening between the two visible in the form of a clear ring." Of the species enumerated by Ehrenberg, Dujardin remarks that "*C. curvata* is so compressed that it is properly referable to our genus *Crumenula*." *C. glauca* and *C. fusca* he regards as doubtful species.

Perty briefly characterizes his genus *Cryptomonas* thus:—"Body an elongated urceolus, from the anterior and mostly-rounded extremity of which two filaments are protruded, somewhat exceeding the length of the body; within are usually one or more dark nuclei, from which the vesicular germs seem to be developed."

CRYPTOMONAS *curvata*.—Green, compressed, slightly bent like the letter S, and twice as long as broad. Amongst Conferva. 1-570".

C. *ovata* (*Enchelys viridis*, M.) (XVIII. 29).—Green, depressed oval, and twice as long as broad; motion slow, vacillating, and rotating on the longitudinal axis, but when obstructed (says Ehrenberg) is seen to leap; lorica paper-like, not hard; numerous internal transparent vacuoles and green granules. In the middle of the creature there are two or three egg-shaped nuclear bodies, and at the posterior part a single vesicle; self-division not observed. Found amongst Conferva. 1-570".

C. *erosa*.—Green, hyaline anteriorly, depressed, oval. In clean water among Conferva. 1-960".

C. *cylindrica* (*Enchelys viridis*, M.).—Elongated, subcylindrical, three times as long as broad. Amongst Confervæ. Almost 1-1000″.

C. (?) *glauca*.—Oval, twice as long as broad; anteriorly truncated with a double flagelliform proboscis; body turgid, and of a bluish-green colour. Found with *Chlamydomonas Pulvisculus*. 1-864″.

C. (?) *fusca*.—Oval, turgid, and of a brown colour. Amongst Confervæ. 1-1500″.

C. *lenticularis*.—Orbicular, resembling a lens; colour green; lorica thick. 1-1729″.

The following are described and named by Dujardin:—

C. *Globulus*.—Globular, green, often with folds (stripes), the diaphanous envelope nearly filled. 1-2600″ to 1-2250″. This species, in Perty's opinion, is a sporule of a plant, or a 'sporozoid.'

C. *inæqualis*. — Ovoid, green, of less thickness than breadth, with a longitudinal depression, and one or two unequal notches in the coloured portion, which is always smaller than the envelope. 1-2600″. In stagnant sea-water, imparting to it a green colour.

C. (LAGENELLA) *inflata*.—Ovoid, enlarged posteriorly, contracted anteriorly; envelope transparent, thicker about the anterior neck-like portion, filled with a green substance, having a central red speck; motion zigzag. 1-1180″. In a vessel of marsh-water with *Lemna*.

C. (LAGENELLA) *euchlora* (XVIII. 31).—Ehrenberg has described under this name an Infusorium of the same size, differing from the last by its more elongated form, and especially by the green contents more completely occupying the anterior neck-like portion, whereas in ours but a narrow streak is visible.

C. (TETRABÆNA) *socialis*.—Regularly ovoid, green, with a central red point, enveloped by a thick diaphanous lorica; commencing self-division frequently seen; occurs in regular groups of four individuals, simply agglutinated, and having their filaments directed all to the same side. 1-1700″ to 1-1300″. In a water-butt in the King's garden, Paris. "I should have taken," says Dujardin, "the specimens of *Tetrabæna socialis* at first for *Gonia*, if a trace of a common enclosing envelope had been found; yet I cannot doubt that they have the closest analogy with the true *Gonia*, and with what Ehrenberg has called *Syncrypta* in his family Volvocina. One may suppose that the commencing self-fission observed in some individuals would give rise to such groups upon the destruction of the lorica (integument) in these different genera. This mode of propagation occurs undoubtedly in most of those having a soft gelatinous integument; but in animals like *Trachelomonas*, whose lorica is hard and brittle, we cannot understand how multiplication does take place."

In the addenda to his treatise, Dujardin has this remark: "I am convinced that my *Cryptomonas* (*Tetrabæna*) belongs rightly to *Gonium*."

The generic characters of *Cryptomonas*, as understood by Perty, have been detailed; the following are the species he describes:—

C. *polymorpha*.—Is so very variable in form that no single description can be applied to it. It ranges between 1-840″ to 1-300″ in length, and may be green or colourless, brown or golden yellow, and contain at one time red specks, at another not. The smallest are usually yellow or of a verdigris-green: many small ones are hyaline; the largest sea-green and brown. These changes of colour are doubtless due to the chorophyll developed within these minute organisms, and to the modifications this matter undergoes in different stages and conditions of life—a subject well examined and illustrated in Braun's work on Rejuvenescence in Nature. In figure, individual specimens are oval or globular, compressed, and emarginate. Small ones move rapidly, frequently in circles; larger examples more slowly, and at times backwards. The species is common among Confervæ the whole year, and under the ice in winter. Perty assumes it to represent the following species of *Cryptomonas* named by Ehrenberg, viz. *C. curvata*, *C. ovata*, *C. erosa*, *C. cylindrica*, *C. glauca*, and *C. fusca*, and also *Chilomonas Paramecium*.

C. *dubia.*—Quite flattened, elliptical, not rounded anteriorly; of a clear green colour, with a hyaline central band, and, in most instances, a red stigma. Movement rather quick; the filament not seen. 1-1900" to 1-1400". It is allied to *Cryptoglena pigra*, *C. cærulescens*, and, in a less degree, to *C. conica* of Ehrenberg.

C. *urceolaris* (Smarda).—Belongs, by reason of its firm testa, to the Thecamonadina.

Genus OPHIDOMONAS.—Body filiform; eye-speck absent; lorica smooth, obtuse, and tubular with a single filament; self-division transverse and complete; internal vacuoles numerous. Its extremely small transverse diameter is the great impediment to a better acquaintance with this being. (It has not been figured.)

OPHIDOMONAS *Jenensis.*—Very thin, incurved spirally, and equally obtuse at both extremities; colour olive-brown; motion brisk. In well-water. 1-570".

O. *sanguinea.*—Very slender, the interspaces between the vacuoles filled with a red colour. 1-576". In brackish water.

Genus PROROCENTRUM (XVIII. 30).—Lorica resembling a little box (*urceolus*), smooth, pointed at the anterior extremity; eye-speck absent; proboscis filiform; vacuoles numerous. Self-division has not been observed. "It is worthy of remark," says Ehrenberg, "that the only species of this genus with which we are acquainted [*i. e.* in 1838] belong to the luminous creatures of the sea, which, perhaps from some peculiar organic relation or condition, yet unknown to us, are instrumental in producing that curious and certainly vital phenomenon usually termed phosphorescence." It may be further noticed, that all the luminous Infusoria of the sea, hitherto discovered, are characterized as being of the same yellowish waxy colour as the best-known species of this genus—*P. micans*; and it is probable that this condition is immediately connected with the interesting phenomenon in question.

PROROCENTRUM *micans.* — Oval and compressed, attenuated posteriorly, but dilated and pointed anteriorly; colour of yellow wax. In sea-water. (XVIII. 30). Two figures, magnified 300 diameters; the first is a side view, the latter a back view; the filament in the former indicates the position of the supposed mouth. 1-430".

P. *viridis.*—Ovate, suborbicular, turgid; posterior end rounded; anterior shortly pointed; colour green. 1-1100". In the Baltic.

Genus LAGENELLA (XVIII. 31).—Distinguished from other loricated monads by the lorica being extended anteriorly, or flask-shaped. The lorica is perfectly distinct, and crystalline. Within are the bright-red speck and green granules. (Vide *Cryptomonas Lagenella*, p. 508, and *Chonemonas*, Perty, p. 513.)

LAGENELLA *euchlora* (XVIII. 31). — Oval, neck short and truncated; lorica crystalline; colour green. Amongst Confervæ. 1-1200".

Genus CRYPTOGLENA (XVIII. 32).—Lorica open, in the form of a shield (*scutellum*), folded or rolled inwardly at the sides, and without a projecting neck. Eye-speck distinct; granules green in all the species. In *C. conica* two oval greyish masses are seen in the centre, and also two filaments. Self-division not observed. These characters, given by Ehrenberg, are valueless to distinguish *Cryptoglena* from other Cryptomonadina, or from *Chlamydococcus*. The scutellar form of the lorica is an error; for it forms a complete investment, interrupted only at the point where it gives exit to the filaments. The red eye-speck is no distinction, as so often remarked; and the absence of a neck-like extension of the lorica is seen in *Cryptomonas*, *Chlamydococcus*, and other genera. Carter describes one species with four filaments. We unite with Dujardin in rejecting this as an independent genus.

CRYPTOGLENA *conica* (XVIII. 32).—Conical, anteriorly dilated and truncated; filaments two, half the length of the body; posterior end acutely attenuated. Colour bluish-green. Abundant in river water, in company with *Cryptomonas glauca*, from which they are readily distinguished by their form, larger size, and red eye. They move briskly in the direction of the longitudinal axis of their bodies, but when obstructed spring or leap out of their direct course. 1-1100″.

C. *pigra*.—Oval, approaching to globular, and emarginate anteriorly; colour a beautiful green; movement slow. In water when covered with ice. 1-3000″.

C. *cærulescens*.—Depressed, elliptical and emarginate anteriorly; colour bluish green; motion quick. Amongst Confervæ. 1-6000″.

Mr. Carter has added and figured some new species, viz.—

C. *lenticularis* (*A. N. H.* 1858, p. 253).—Spherical, compressed; lorica distinct and stout; endochrome separated from it by a distinct clear zone; contractile vesicle seated at the point of insertion of the two filaments, where there also seems to be an interruption in the continuity of the lorica (emarginate); eye-speck on one side, nucleus visible. The horizontal view is ovate, and acuminate at both ends. Fission takes place in the power of two, just as in *Chlamydococcus*, from which indeed no satisfactory distinctive features are perceptible in the engravings furnished.

C. *cordiformis*.—Distinguished by its cordiform lorica. The contents are orbicular, and do not nearly fill the lorica; filaments four; a resting-stage perceived, wherein the contents are covered by a thick envelope, and are divided into numerous cells (microgonidia.)

C. *angulosa* (*A. N. H.* 1859, iii. 18).—Lorica compressed, oblong, angular, shield-shaped, transparent, round posteriorly, square anteriorly, where it presents a short neck in the median line for the passage of the cilia; border thin, curled up posteriorly and anteriorly on opposite sides. Internal or green cell at some distance from the lorica, angular, lined with chlorophyll, provided with two cilia, which issue through the neck of the lorica; two contractile vesicles at their base; an eye-spot median and peripheral, and one to four starch-cells of a circular form. Swimming with its cilia forwards in an extremely irregular line. Length of lorica 1-1080″, and breadth 1-1800″. Freshwater tanks in the island of Bombay.

Genus TRACHELOMONAS (XVIII. 33, 34; XIX. 9–11).—Have a single long filament, an eye-speck, and a closed elongated or spherical lorica, without a projecting neck. Very minute transparent vesicles have been discerned in *T. nigricans* and *T. volvocina*. It is probable that some of the highly interesting animalcules which enter so abundantly into the silicified substances in certain chalk formations belong to this genus. The genus *Trypemonas* (Perty) is equivalent to this, the characters of which are hereafter given at large in Perty's words (p. 513).

TRACHELOMONAS *nigricans*.—Oval, approaching to globular; colour rarely green, mostly of a reddish or blackish brown. Eye-speck brown. 1-1700″.

T. *volvocina* (XVIII. 33, 34; XIX. 9, 10).—Spherical, with a delicate filament; colour mostly green, sometimes of a brownish hue, with a distinctive red ring around the body: between the internal vesicles is a very fine granulated substance, to which the colour of the body is due. The red circle, so remarkable a feature in this species, always appears in the same horizontal position, how quickly soever the creature may be revolving on its long axis. The uppermost figure represents the flabellum extended; in the next it is retracted; the lowest of the three is a very young specimen; and 34, a full-grown one that has been forcibly pressed and the lorica broken. Amongst Confervæ. 1-860″.

T. *cylindrica* (XIX. 11).—Oblong, approaching to cylindrical; filament almost as long as the body. Colour a beautiful green; eye-speck red; ring purple. 1-1000″. Perty points out the fact that *T. nigricans* is nothing more than an old specimen of this species, brown and opake by age.

T. *areolata*.—Globose, surface areolated.

T. *aspera*.—Similar to preceding, but its surface covered with rough points.

T. *granulata*.—Similar, but its surface very minutely granulated.

T. *lævis*.—Globose, with its surface smooth. The assigned differences between the surface of this and the two preceding are too trivial to be characteristic.

T. *pyrum*. — Oblong or pear-shaped (pyriform), smooth.

Dujardin, in his family Thecamonadina, includes some genera of animalcules not described by Ehrenberg, or described by him under different names and according to a different arrangement. They are appended here as best agreeing with the Cryptomonadina.

Genus PHACUS (D.).—Body flattened, leaf-like, and mostly green. It displays a red speck in front, together with a flagelliform filament; and the resistant membranous integument is prolonged posteriorly in the form of a tail.

"Three out of the four species are referred by Ehrenberg to his genus *Euglena*, on account of similarity in colour. The difference between the two genera is, however, considerable; for in *Euglena* the integument is contractile, and permits of a frequent change of form, whilst in *Phacus*, on the contrary, the integument appears quite wanting in contractility, and the animal invariable in form.

"The enclosing integument of *Phacus* persists after the death of the animal and the destruction of the contained green mass, and also after the action of various chemical agents, becoming, in the latter cases, quite transparent. The motor filament disappears with the living contents; globules of the latter remain after death."

Mr. Carter (*A. N. H.* 1856, xviii. p. 241) describes a single, glairy, discoid, capsuled body in the centre of *Phacus*, as well as in the large lip of *Crumenula texta*.

1. *Phacus pleuronectes* = *Euglena pleuronectes*; 2. *P. longicauda* = *E. longicauda*; and 3. *P. triquetra* = *E. triquetra*. (See EUGLENA.)

The new species, of which the characters are given, is

PHACUS *tripteris*. — Oblong, with three longitudinal plaits meeting along the axis, rather twisted on the midrib, with a red speck in front and a diaphanous caudiform prolongation behind. 1-420" to 1-312".

Genus CRUMENULA (D.) (XXVI. 6).—Oval, compressed, covered by a resistant integument (testa) apparently reticulated, sending out a long flagelliform filament obliquely from a notch in the anterior border. Motion slow. There is no tail-like prolongation, as in *Phacus*. A contractile vesicle present.

CRUMENULA *texta*. — Envelope reticular, filled with a green matter, together with vacuoles or hyaline globules, and having a large red globule anteriorly. 1-520". Testa persistent after death.

In this species Mr. Carter (*op. cit.* p. 119) describes an inner layer of pointed sigmoid fibres arranged parallel to each other, so as to form a conical cell, which remains behind when the softer contents have dispersed.

The anterior notch is produced by a sort of overhanging lip. The filament is three times longer than the body.

Genus DISELMIS (D.).—Ovoid or globular, covered by an integument, not contractile, of almost gelatinous consistence; two equal locomotive filaments proceed from the anterior extremity.

"This genus nearly corresponds to the *Chlamydomonas* of Ehrenberg, placed by him in the family Volvocina by reason of its apparent self-division into two or four segments within the testa. Dujardin, on the other hand, admits none as Volvocina which do not exhibit an aggregation of perfect individuals within a common envelope."

The removal, by Dujardin, of the Chlamydomonads described under this name of *Diselmis*, from Volvocina to Cryptomonadina, is generally held to be an error, dependent on an imperfect conception of their characters and true affinities. (See genus CHLAMYDOMONAS.)

The integument of *Diselmis* is non-resistant, diaphanous, breaks up after death by diffluence, and is sometimes filled with a green substance. Like plants, these beings are sensitive to light, fix themselves to the lightest part of the containing vessel, and disengage oxygen when exposed to the sun's rays. In the green substance are seen granular masses, a disk with an expanded border, and a red speck. The motor filaments proceed from the same opening of the integument, and often form a diaphanous lobe projecting from the opening. The red colour oftentimes seen in the water of the Mediterranean appears due to Infusoria of this genus.

DISELMIS *viridis* = *Chlamydomonas pulvisculus* (Ehr.) (XIX. 16).

D. *marina*.—Nearly globular, obtuse and rounded in front, granular within. 1-1050''.

This species is larger than *D. viridis*, more globular, and apparently deficient of the red speck. In stagnant sea-water of a green colour.

D. *angusta*.—Pyriform, oblong, appearing to be plaited and tubercular inside, sometimes with an indistinct red speck. 1-2600'' to 1-1850''.

D. *Dunalii*. — Oval or oblong, often constricted about the middle; colourless when very young, then green, afterwards red; with 2 flagelliform filaments longer than the body, seated on a projecting and retractile anterior lobe. Interior occupied by coloured globules. Discovered by M. Joly to be the chief cause of the red colour of the water of the Mediterranean.

Genus ANISONEMA (D.) (XIX. 8; XXVI. 8).—Colourless, oblong, more or less compressed, having a resistant envelope giving exit by an opening to two filaments, one directed forwards and flagelliform, the other trailing backwards and retractile; movement slow.

"In other genera, as in *Heteromita*, two similar filaments exist; but the present genus is known by its non-contractile resistant integument, which is often met with empty and transparent. It may be that the *Bodo grandis* (Ehr.) is allied to this genus as well as to *Heteromita*."

ANISONEMA *Acinus* (XIX. 8).—Oblong, depressed, rounded posteriorly, and narrower in front, like the seed of an apple, with an opening close to the apex; colourless and transparent, except a few vesicles, mostly green, but occasionally red; movement in a straight line forwards. 1-1300'' to 1-850''. In pond-water. This species = *Bodo grandis* (?) (Ehr.). Perty gives a figure of an organism he identifies with this species, having four filaments anteriorly and none trailing: he supposes it in the act of fission; but his figure does not show it.

A. *sulcata* (XXVI. 8).—Oval, depressed, with 4 to 5 longitudinal furrows, and an oblique notch in front, from which the two filaments proceed; movement vacillating, circular. Perty has seen it divide longitudinally. 1-1300''. The projecting filament is three times, and the floating one about twice as long as the body; in this, however, says Perty, there is no constancy.

Genus PLŒOTIA (D.) (XXVI. 10, *a*, *b*).—Diaphanous, having several ribs or longitudinal ridges along the middle, and a circular translucent margin, giving the whole a navicular form; two locomotive filaments proceed from one end.

This distinct form might be mistaken for one of the Bacillaria, were not the filaments clearly visible. The characters of the filaments are similar to those of *Anisonema*—one extending forwards with an undulatory movement, the other trailing and capable of suddenly arresting the movement of the body by its adhesion and power of retraction.

PLŒOTIA *vitrea* (XXVI. 10 *a*, *b*).—Hyaline, with 3 to 4 longitudinal salient lines at the centre, and some granules. 1-130''; movement slow. In sea-water kept for two months.

Genus OXYRRHIS (D.) (XXVI. 9 *a*, *b*). — Ovoid, oblong, obliquely notched in front, and prolonged into a point; several flagelliform filaments proceed laterally from the bottom of the fissure.

The name is indicative of the elongated apex. These Infusoria being but imperfectly known, one species only is described:—

OXYRRHIS *marina* (XXVI. 9 *a*, *b*.)—Colourless; subcylindrical rugose, rounded posteriorly. 1-520″. In the Mediterranean.

The next three genera are taken from Perty, the first being one of his Cryptomonadina, the others Thecamonadina:—

Genus PHACOTUS (XIX. 7, *a*, *b*, *c*).—Body round, biconvex, with two (possibly four) filaments.

PHACOTUS *viridis*.—Green, usually divided through the middle by a clear or a dark line. Margin acute; the central part more or less convex, sometimes elevated into a sharp angular ridge, rendering the figure four-sided. The shell shows a double contour, and persists some days after the death of the individual. Medium size 1-1440″. Among Confervæ. Bern. It = *Cryptomonas lenticularis* (E.). Like Dujardin, Perty removes *Chætotyphla* and *Chætoglena* from the Peridiniæa to the Thecamonadina. The former genus he retains, but merges the latter in his group *Chonemonas*.

Genus TRYPEMONAS = generally TRACHELOMONAS (Ehr.) (XIX. 9, 10, 11).—Shell globular or elliptic, with a small round aperture (the elevated margin of which frequently produces a funnel-like appearance), from which the filament protrudes; colour green, with a red stigma; lorica at first hyaline, then purplish, and lastly brown, thick and opake; not armed, but apparently porous from the presence of numerous puncta indicating the absence of deposit, as elsewhere. Perty justly objects to the term *Trachelomonas*, as prone to cause confusion of ideas from its etymology signifying beings with necks, which none of those it includes possess.

TRYPEMONAS *volvocina* (XIX. 9, 10) = *Trachelomonas volvocina*; and *T. cylindrica* (XIX. 11) = *Trachelomonas cylindrica* and *T. nigricans* (Ehr.).

Genus CHONEMONAS (XVIII. 35 *a*, *b*, *c*, *d*).—Green with a red stigma; testa hard, ellipsoidal, with a funnel-shaped opening at the anterior end—from which *two* filaments proceed. It represents in part the genera *Chætoglena*, *Pantotrichum*, and *Lagenella* (E.).

CHONEMONAS *Schrankii* (XVIII. 35 *a*, *b*, *c*, *d*), formerly named *C. hispida*.—Lorica clear or dark brown, more or less spinous. Filaments double the length, and hyaline. Portions of the lorica exhibit apparent pores, and empty specimens often decussating lines. The green contents escape unhurt on fracturing their enclosing case, which they generally do not fill. When fission proceeds, the contents alter their form, and the filaments disappear. Onward movement not rapid, seldom oscillating, but actively revolving. 1-900″ to 1-540″. At Bern, in pools of snow-water, and beneath the ice. Two varieties occur:—*a. glabra*, with a smooth lorica, which is no other than the *Lagenella euchlora* (E.); *b. unifilis*, with a single filament, equivalent to *Chætoglena volvocina* (E.). The very hispid examples of this Chonemonas are = *Pantotrichum Lagenula*, placed by Ehrenberg among his Cyclidina.

C. *acuminata*.—Shell oval, strongly pointed posteriorly; bristles scarcely observable. Funnel at front distinct. 1-500″. Hyaline and quite smooth specimens also occurred. On the St. Gothard.

Genus DREPANOMONAS (Fresenius).

DREPANOMONAS *dentata*.—Colourless; falciform, compressed; pointed at each end, with five outspreading furrows, of which two are on either flat side, and one on the convex edge. In the centre of the concave surface is a ventricose swelling with a small tooth-like process; a similar process is remarked beneath the apex. From near the last, several lines extend upwards and outwards. In one aspect an undulating line is perceptible along the convex margin; this is also visible in the loricæ of dead specimens. Internally are only colourless granules, imparting a pearly hue. On one occasion a vacuole was seen having a reddish glimmer; possibly a contractile vesicle; movements slow; no contractions of figure observed. Both ends furnished with delicately motile filaments, those on the anterior longer than those on the posterior extremity; but still seen with difficulty. In swimming it lies on the flat surface; it also revolves on its long axis. 1-15''' to 1-14'''. In water from Walldorf.

FAMILY IV.—VOLVOCINA. (See p. 144.)
(XIX. 32–69; XX. 22–47).

THIS family derives its name from the genus *Volvox*, and from the *rolling motion* with which the beautiful creatures belonging to it make their way through the water. They resemble the Monads in most particulars relating to their organization; have an unvarying form, and, except a filament, no appendages; vacuoles present. Whilst propagation by self-division is proceeding, and the young are increasing in size, the surrounding envelope or lorica is observed to expand in a corresponding degree, but continues entire until its numerous occupants have come to maturity, when it bursts and sets them at liberty.

All the genera are provided with organs of locomotion, which consist, as with the Monads and Cryptomonads, of a single or double very delicate filament; and hence it is that when they are clustered, the entire group appears to be ciliated, or beset with hairs. Besides granules, one or two round nuclei and a contractile sac are present.

This family Ehrenberg disposed into ten genera—five furnished with a red stigma, situated at the anterior part of the body, and five without it. In the former, a sensitive system was presumed on the supposition of the red speck being an eye.

The following is an analysis of the family:—

- Eye absent.
  - Tail absent
    - Lorica single
      - Lorica box-like
        - vibrating filament absent ... Gyges.
        - vibrating filament present ... Pandorina.
      - Clusters tabulated or in plates ...... Gonium.
    - Lorica double .... Syncrypta.
  - Tail present .... Synura.
- Eye present.
  - Self-division both equal and perfect (no internal globes)
    - Tail present .... Uroglena.
    - Tail absent ...
      - filament single ... Eudorina.
      - filament double ... Chlamydomonas.
  - Self-division unequal (forming internal globes)..............
    - Filament single .... Sphærosira.
    - Filament double .... Volvox.

The above account, derived from Ehrenberg's work, affords a very imperfect conception of the Volvocina, especially of their structural characteristics as a family,—a defect we have endeavoured to supply in the chapter on their general history (p. 144). Moreover, as there noticed, these beings are numbered by the majority of naturalists, at the present day, among plants, although a respectable minority, among whom are Thuret and Lachmann, incline to the opinion that they are for the most part animals, as Ehrenberg represented. Thuret expressed this opinion now several years since, when the physiology of the simplest vegetable organisms was imperfectly understood, and supported it on the fact that an act of germination, similar to that seen among the spores of the lower Algæ, was never witnessed among the Volvocina. This absence of a supposed vegetable characteristic, more recent researches appear clearly to set aside as an argument against the vegetable nature of a doubtful organism; for in the whole cycle of life of many of the simplest, or so-called unicellular plants, an act of germination, as understood by Thuret, never occurs. Dujardin, when he published his work on Infusoria in 1841, admitted the Volvocina among animalcules, but proposed a different distribution of their genera to that put forward by Ehrenberg. Thus, he transferred *Gyges* and *Chlamydomonas*, owing to their not being aggregated within a common envelope, to the Thecamonadina, and united *Eudorina* with *Pandorina* (XIX. 59–69), and *Synura* with *Uroglena*, because he could not regard the presence or absence of a red speck to be a generic characteristic. Further, he considered *Syncrypta* a doubtful genus, and combined *Sphærosira* with *Pandorina*.

Although the present state of science proves that the appearance of a red speck or specks in a monadiform being is mostly a transitory phenomenon, associated with a certain condition or phase of existence, and that therefore the union of *Eudorina* with *Pandorina*, and of *Synura* with *Uroglena*, is a correct proceeding, yet Dujardin erred both in detaching *Gyges* and *Chlamydomonas* (XIX. 16) from the Volvocina, and in considering *Sphærosira* and *Pandorina* modifications of a common form. The relation of *Chlamydomonas* to the Volvocina has been well shown by Cohn, Braun, and others; and *Gyges* itself might probably be dispensed with as a distinct genus, since there is good evidence to show that its species are simply stages of development of *Chlamydococcus* or *Protococcus* (XIX. 20–31), and of *Chlamydomonas*. Again, *Sphærosira*, instead of being a varied phase of *Pandorina*, is a member of the genus *Volvox*; indeed Prof. Busk inclines to the notion that it is merely a developmental stage of the common *Volvox Globator* (*T. M. S.* i. p. 39). Perty, however, advances as an argument for its independent nature, that it is common about Bern, whilst *Volvox Globator* is not met with. This fact speaks at least for the specific independence of *Sphærosira*, although its generic must be given up. Moreover, a genus *Botryocystis* was instituted by Kützing, of the independence of which, however, there is no good evidence. The condition of *Protococcus pluvialis* (Cohn, *Ray Soc.* 1853, p. 559), when divided into sixteen segments, corresponds to the *Botryocystis Morum*. Further, the last-cited author in another treatise (*Entwick. d. Mikroskop. Alg. und Pilze*, p. 209) treats *Botryocystis* as synonymous with *Pandorina*, and in this agrees with Prof. Henfrey, who remarks (*M. T.* 1856, p. 51) that the form of *Pandorina* which produces the resting-spores, after losing its cilia, is Kützing's *Botryocystis Morum*. Perty coins two new genera, called *Synaphia* and *Hirmidium* (XIX. 15). Cohn points out a natural division of the Volvocina into two sections, in the first of which, represented by *Chlamydomonas* and *Chlamydococcus*, the fission of each primordial cell is complete, and the products single and unicellular, whilst in the second section, including all the rest of the Volvocina, the cells formed by the fission of the parent primordial cell continue united in groups or clusters. The difference between the several genera obtains from the disposition of the produced cells; and this, again, depends on the direction of the line of fission. Thus, in *Stephanosphæra* (XIX. 38–52) the plane of fission is the meridian of the sphere; in *Gonium* it occurs in two planes at right angles to each other, and in *Volvox* and its allies in three planes. If the Volvocina are referable to the vegetable kingdom, they constitute a family of the order Palmellaceæ (Chamæphyceæ, *K.*), among the Algæ.

The separation of *Syncrypta* from *Gyges*, and its independent generic existence, are very questionable; for the possession of a double lorica, attributed to *Syncrypta* by Ehrenberg, cannot serve as a generic distinction from *Gyges*, with a single lorica, since Cohn has shown in *Chlamydococcus* that the production of a distinct, loosely investing, and apparently second covering, is one of the series of developmental phenomena in the selfsame being. The same statement is true of the so-called tail which is used to separate *Synura* from other allied forms; for caudate beings make their appearance in the cycle of existence of non-caudate: thus a caudate variety of naked "zoospore" resembling a *Bodo* is represented by Cohn in his illustrations of the multiform phases of *Protococcus*. The presence of a mouth, and the construction of the envelope with one side or end open, through which the animal can protrude itself at will, are statements now generally ignored.

After excluding the inadmissible and the very doubtful genera of this family of Ehrenberg, there remain only *Pandorina*, *Gonium*, *Chlamydomonas*, and *Volvox*. To these, other naturalists add *Chlamydococcus* (Braun), *Glœococcus* (Braun), *Stephanosphæra* (Cohn), and *Stephonoma* (Werneck). Ehrenberg himself has added a new genus he names *Trochogonium*; but, from the imperfect description given, it is not possible to decide accurately whether it is distinct from some of the genera instituted by other naturalists.

Genus GYGES.—Lorica of a simple box-like form (*urceolus*); eye-speck and 'tail' absent; filament doubtfully present; the internal organization is little known. Two species are mentioned by Ehrenberg, both of a green colour and enclosed in a transparent lorica.

GYGES *Granulum* (*Volvox Granulum*, M.).—Oval, or nearly globular; contained granules of a darkish green colour. Amongst Lemnæ and Conferva. 1-1150''.

According to Cohn (on *Protococcus*, p. 559) the encysted motile zoospore (XIX. 31) of *Protococcus* (*Chlamydococcus*) *pluvialis* is the same as this species *Gyges Granulum*; whilst the same zoospores divided into two must be regarded as the next species, *Gyges bipartitus*.

G. *bipartitus*.—Crystalline, gelatinous, and nearly spherical; the superficies colourless, but its granular contents yellowish green; it is sometimes seen divided into two, at others as a simple sphere. Amongst Confervæ. 1-480''.

G. *sanguineus*.—Oval, red, inclining to crimson, surrounded by a broad colourless ring representing the enveloping lorica. This species was discovered by Mr. Shuttleworth in the red snow which fell at the Grimsel in August 1839. Its motion is lively. Group 527 (XVII.) shows several highly magnified. Found with *Astasia nivalis* and *Monas gliscens*, among the globules of *Protococcus nivalis* (*Ed. Phil. Journ.* v., xxix.). 1-1200'' to 1-300''. This is probably only the 'still' phase of *Chlamydococcus pluvialis*.

M. Vogt gives a very singular account of the mode of reproduction of this being. He says, "It gives off from several parts of its body small transparent buds, apparently vesicular, and for the most part filled with granular matter. As they enlarge they become gradually detached; sometimes two of equal size, of which one is red and loricated, the other colourless, adhere by a very narrow point of attachment, which subsequently gives way, and the bud appears as an Infusory animal, like what Mr. Shuttleworth has represented in his 7th and 8th figures, and which approaches *Pandorina hyalina* (Ehr.)."

This account of the reproduction of this species of *Gyges* is so peculiar and exceptional, that the questions arise whether it really is a member of this genus and family, and, if it be, whether the description is a correct interpretation of the facts observed.

M. Vogt adds that *Gyges sanguineus* ought not only to be looked upon as the type of a new genus, but even of a new family, on account of its very peculiar mode of reproduction. He further describes a new species:—

G. *Vogtii*.—Globular, containing in its interior from two to five individuals, enveloped by an apparently silicious lorica; colour dark red; frequently found adherent and arranged in the form of a cross, also often separate. "The small individuals, probably the young, were of a clear yellow hue. I could not observe the slightest motion in them."—On the Animalcules of the Red Snow, *Bibliothèque Univ. de Genève*, May 1841.

Genus PANDORINA (XIX. 59–69) (Part I. p. 157).—Destitute of eye-speck and tail, but provided with a globular lorica and a slender filament. During self-division the creature acquires the appearance of a mulberry. Transparent vesicles occur in one species: two exhibit green, and a third colourless granules.

Dujardin esteems the presence of the red speck to be insufficient to distinguish *Eudorina* as a genus distinct from *Pandorina*; and most recent observers agree with him.

It has been shown by Braun (*Rejuvenescence, Ray Soc.* 1853, pp. 169–209), as well as by others, that Ehrenberg was in error in assigning a single filament only to *Pandorina*, and no eye-speck—since two flabella extend from the more pointed extremity of the being, and close to their base is a brownish-red speck.

Prof. Henfrey details (*M. T.* 1856, p. 49) the characteristics of *Pandorina* much more fully, and corrects the errors into which Ehrenberg fell. He assumes it to be a plant, and thus describes it:—"*Pandorina.*—Frond a microscopic, ellipsoidal, gelatinous mass, containing, imbedded near the periphery, sixteen or more biciliated, permanently active gonidia, arranged in several circles perpendicular to the long axis of the frond. The gonidia, almost globose, with a short beak-like process, a red spot, and a pair of cilia which project through the substance of the frond to form locomotive organs upon its surface. Reproduction: 1. By the conversion of each gonidium into a new frond within the parent mass. 2. By the conversion of the gonidia into encysted resting spores, which are set free, and (?) subsequently germinate to produce new fronds." The genus more closely resembles *Stephanosphæra* than any other of the family.

PANDORINA *Morum* (*Volvox Morum*, M.) (XIX. 59–69).—Body simple or multipartite, enclosed within a simple lorica. Colour green; filament twice as long as the body. In water with Lemnæ and Confervæ. Size of individual 1-1150″, cluster 1-120″. Some individuals broken from the cluster by Ehrenberg have not been above one-third the former measurement.

P. Morum is much more satisfactorily and correctly described by Mr. Henfrey, thus:—"Fronds hyaline, from about 1-80″ downwards. Gonidia either 16, and then arranged into circles of 4; or 32, and then in 5 circles—2 at the poles, of 4, and the intermediate 3 of 8 gonidia; which, in the perfect form, stand near the periphery, and wide apart. In the forms which produce the resting-spores, the gonidia are crowded together in the centre. The gonidia are green; but the contents of the resting-spores, after they have become encysted, are converted into oily and granular matter of a bright red colour."

P. *hyalina.*—Form globular. In the Nile with Confervæ, and is a doubtful species. 1-5760″.

Genus GONIUM (XIX. 32–37; Part I. p. 152).—Deficient both of eye-speck and tail; lorica simple; in the process of self-division, form regular four-cornered tablets or plates. The lorica (a *lacerna*) of each individual (as is seen after its separation) is nearly round; and the organism can cast it off and form it anew. In one of the species (*G. Pectorale*), two vibratory filaments are placed at the mouth as organs of locomotion, &c.; in the other species these have not been observed. Vacuoles are seen within *G. Pectorale*; and a red speck (produced probably by refracted light) at the base of the filaments has been conceived by Ehrenberg to indicate the mouth.

Cohn's elaborate account furnishes the following additional notes on *Gonium* (*Entwick.* p. 179; and Part I. p. 152):—The quadrate tablets consist of sixteen polygonal (mostly hexagonal) cells, united together by tubular prolongations from their angles, the whole being surrounded by a common gelatinous investment (the envelope-cell). Each cell or gonidium has its own hyaline membrane, is somewhat elongated into a neck-like form on one side, and contains a homogeneous protoplasm, chlorophyll, and dark granules (except in the neck-like portion), and in the centre a single chlorophyll vesicle; besides these, several vesicular spaces, and one, two, or rarely three contractile vesicles. From the pointed end two filaments proceed, and pierce the common envelope, to vibrate freely on the outside of the tablet. Reproduction by fission is not a simultaneous act, as represented by Ehrenberg, but is effected by repeated divisions through four generations or series, in each of which the 'daughter cells' severally resolve themselves into two others, as happens in all the Volvocina and Palmelleæ. The result of this act of reproduction, when uninterfered with and complete, is the formation of sixteen tablets similar to the parent, but without any organic connexion, each young tablet, however, being enclosed within the wall of the parent cell, out of which it has been produced, for this cell-wall takes no part in the process of fission. Sometimes a tablet breaks up, setting its component gonidia free, when, their angular processes becoming absorbed, and their membrane further removed from the contents, they assume the general aspect of a *Chlamydococcus* or *Chlamydomonas*, and probably enter on a resting-stage like the gonidia of *Stephanosphæra*. Ehrenberg believed the isolated cells to be reproduced by fission like those united in the tablets; but Cohn never observed this take place. If this resting-stage actually occurs, then *Gonium* is propagated by 'macrogonidia'; but of 'microgonidia' no evidence has been discovered. The tablets revolve on their shorter axis, and hence, on a polar aspect, appear like a disk, on an equatorial like a line of cells. A peculiar structural relation obtains between *Gonium* and *Pediastrum*. Lastly, Cohn asserts that *Gonium Pectorale* is the only true species of this genus; that the others enumerated by Ehrenberg are motionless, and belong to the genus *Merismopedia* among the Palmellaceæ.

GONIUM *Pectorale* (M.) (see p. 152).—Consists of sixteen spherical bodies enclosed within a transparent lorica, and disposed regularly in a quadrangular form, and in the same plane, like the jewels in the breast-plate of the Jewish High Priest, whence the specific name. The four central ones are generally larger than those which surround them; and the combined diameters of the three smaller balls are about equal to the two larger centre ones to which they are attached; the external corners are consequently vacant. As these animalcules swim and revolve in the water, they occasionally present a side view to the observer, when the circumference of the larger central globules may be seen projecting beyond the others. Sometimes the clusters appear irregular. They are of a beautiful transparent green colour; and in swimming, the globules often appear of an ellipsoidal figure.

In order to observe the structure of this highly curious and beautiful creature, considerable adroitness is necessary in the management of the microscope; while a little indigo conveyed into the water with the point of a camel's-hair pencil will be required to see the whorls and currents set in motion around it.

The single animalcules (XIX. 33) swim like the Monads, in the direction of the longitudinal axis of their bodies; but the tablets have a variety of movements: sometimes they move quite horizontally, at others vertically, at others again on their edge, revolving like a wheel. A magnifying power of 200 diameters is sufficient for general examination; but to exhibit all the structures shown in the engravings, four times that power will be required. In clear water, salt and fresh, near the surface. Discovered by Müller in clear water at Copenhagen, 1773. Size of animalcule from 1-460″ to 1-1150″, of tablet not exceeding 1-280″.

G. *punctatum.* — Corpuscles green, spotted with black, and enclosed within a crystalline lorica. Amongst Confervæ. 1-4600″; a tablet of 16, 1-570″ in breadth.

G. *tranquillum.* — Corpuscles green, within a crystalline lorica, each 1-2880″; a tablet of 16 corpuscles, from 1-140″ to 1-220″ in breadth. Tablet sometimes twice as broad as long.

G. *hyalinum.*—Corpuscles transparent,

within a crystalline envelope. In stagnant water. Corpuscles 1-3000"; tablet of 20 to 25, 1-600" in breadth.

G. *glaucum.* — Corpuscles bluish-green, within a crystalline envelope. The number of animalcules in the tablets varies from four to sixty-four. In sea-water. Size 1-5000"; tablet 1-500" in diameter.

Gonium tranquillum and *G. glaucum*, says Perty, are Algæ (*i. e.* he would say, are not members of this genus). He adds as a new species,

G. *helveticum.* — The green, spherical corpuscles combined in a tabular, gelatinous envelope, without any intercommunicating bands, each furnished with a fine red stigma and two ciliary locomotive filaments. On a polar view, one large round vesicle is visible; on the lateral aspect, two such are apparent, one larger than the other. On drying the specimen, the stigma itself assumes the form of a vesicle. It is readily distinguished from G. *quadrangulatum* by the absence of the connecting bands or tubules between the several corpuscles in the tablet. Diameter of tablet 1-360", of corpuscles 1-1300". Filaments 2½ times longer than the gonidia. In ponds about Bern.

Genus SYNCRYPTA (XX. 26–28).—This genus is mainly characterized by secreting or hiding itself (as the name implies) within a second envelope. Each individual is provided with a special lorica of the form of a little shield (*scutellum*), and is united with others in a common gelatinous envelope (*lacerna*) into which it can retreat; neither eye-speck nor tail is present, but there is a large filament; self-division longitudinal. The filaments of the several corpuscles give the cluster an appearance of being surrounded with hairs.

With this genus Dujardin would identify his *Cryptomonas* (*Tetrabæna*). The very doubtful position and independence of this genus as a member of the Volvocina have been remarked on in the general notes on this family (p. 144). Mr. Carter, in a paper lately published (*A. N. H.*, 1859, iii. p. 1 *et seq.*), represents *Syncrypta* to be the "spermatic form" of *Volvox* or of *Sphærosira* (Ehr.). (See notes on SPHÆROSIRA.)

SYNCRYPTA *volvox* (XX. 26–28). — Form oval; colour green, with whitish rays in the centre. Generally in water drained from Confervæ. 1-2880"; a clustered globule in its crystalline tunic, hardly exceeding 1-570". Fresenius states that he has seen a red stigma in each corpuscle, which was overlooked by Ehrenberg.

This berry-like cluster of animalcules, when rolling through the water, is a beautiful object for the microscope; and with the aid of a little indigo, the numerous currents it creates are readily perceived: XX. 27. magnified 260 diameters; fig. 26. 400; and fig. 28 a cluster about to sever into four.

Genus SYNURA (XX. 29, 30).—Eye-speck absent; tail filiform, attached either to the base of its own lorica or to the centre of the cluster to which it belongs. The general envelope is spherical, gelatinous, and is hollowed out by as many compartments or cells as there are individuals in the little community. From out of these cells they can stretch themselves a considerable distance, whilst they continue attached by the extremely delicate and extensible tail. This so-called tail or pedicle is homologous with the connecting rays or threads of the several corpuscles in the globe of *Volvox*, and is, like them, a production of the protoplasm of the interior. As before remarked, this genus is doubtfully retained; for the chief distinctive feature Ehrenberg insists on, viz. the presence of a double lorica, loses its significance now that modern researches have shown that the formation of a second or common envelope is an ordinary phenomenon at a certain stage of existence of most or of all Volvocina. Moreover, the description given of this genus is too loose and faulty, and its accompanying illustrations too rude, to render it possible to rightly appreciate its characters and to assign it its proper place, even if it is admitted to be an independent organism. Mr. Carter has lately published (*A. N. H.* 1859, iii. p. 10) the opinion that *Synura* is the "spermatic form" of *Volvox* or of *Sphærosira*. (See notes on SPHÆROSIRA).

SYNURA *uvella*.—Corpuscles oblong, yellow, capable of extending themselves to three times their usual length, by means of the extensile tail. The cluster has the form of a mulberry, and its motion is rolling like that of *Volvox Globator*. xx. 29, xx. 30, show a portion of a cluster, and the manner in which the tails are inserted in the common envelope. This species, along with *Syncrypta* and *Uroglena Volvox*, may have often been confounded with *Uvella virescens*. Length, exclusive of tail, 1-700"; diameter of cluster from 1-190" to 1-280".

Genus UROGLENA (XX. 31).—The members of this genus, unlike other Volvocina, possess both an eye-speck and tail; they live in clusters under a common envelope (*lacerna*), which is subdivided into cells for the accommodation of the several individuals. Self-division takes place simply and equally in these individuals, whilst in their clustering condition. They are placed at uniform distances from each other, attached by their tails, which radiate from the centre. Each monad is furnished with a filament, which projects externally and gives to the entire group the appearance of being covered with hairs. When the creatures divide, the mantle or lacerna enlarges only, and does not itself undergo fission. The red speck is in the fore part of the body; the tail is filiform, resembling that of *Vorticella* and *Bodo*.

The tail mentioned in the above description is the same as that of *Synura*: the use of the term is very inappropriate in both cases. It may be that *Uroglena* should be united with *Synura* as Dujardin proposed, since the presence of an eye-speck in the former and its absence in the latter is not distinctive; still we know too little of the being which Ehrenberg would call a *Uroglena*, to come to a decision respecting its affinities and generic independence.

This genus is another which Mr. Carter would set aside, as he considers it (*A. N. H.* 1859, iii. p. 10) the same with *Sphærosira*, or the "spermatic form" of *Volvox*. (See notes on SPHÆROSIRA.)

UROGLENA *Volvox* (xx. 31).—Corpuscles yellow, oblong; tail extensible, from three to six times the length of the body, and even more; cluster mulberry-shaped. There is little doubt that single corpuscles of this genus have often been taken for creatures of a different family. Ehrenberg states that he has observed individuals with two or three coloured specks, which he conceives to have been a symptom of approaching self-division. In turf water. Diam. of cluster 1-90".

Genus EUDORINA.—Has no tail, but possesses a distinct eye-speck, and a simple vibratory filament anteriorly. Self-division proceeds simply and equally, whilst the corpuscles retain their clustered condition. They are periodically able to cast off their globular envelope (*lacerna*), and to exude a new one, like certain Annelida. To observe the eye-speck, a power of 300 diameters must be skilfully employed.

Dujardin's proposition to combine *Eudorina* with *Pandorina* has been already mentioned (p. 515), and appears to be a correct one. The assigned characteristic difference between those two genera is worthless; for *Pandorina*, like *Eudorina*, has a coloured speck (see p. 157 *et seq.*).

EUDORINA *elegans*.—Corpuscles green, globular, never protruding from their cells beyond the common envelope. Stigma sparkling red. The clusters, which are of an oval or globular form, contain generally from 30 to 50 individuals, and never less than 15. Motion revolving. Fig. 47 exhibits the filaments extended, and the bodies of the animalcules within the lacerna (*i. e.* the "common envelope"). Clusters of these beautiful animalcules are often seen in such amazing numbers, along with the *Volvox Globator* and *Chlamydomonas Pulvisculus*, as to render the water (otherwise colourless) of a decided green colour, especially towards its edges. They are exceedingly delicate—so much so that it is difficult to preserve them alive for more than a day or two: whenever it is attempted to retain them in large quantities, the second day will generally exhibit a thick mass of dead ones at the bottom of the vessel. When a few only remain alive, if the stale water be poured away, and they are removed into a vessel of clear water, they will live for weeks. At Hackney and Hampstead; most abundant in the spring of the year. Diam. of cluster 1-180".

Genus CHLAMYDOMONAS (XVIII. 40, 51–54; XIX. 16) (Part I. p. 146).—Tail absent, eye-speck distinct red, filament double; multiplication takes place by self-division within the common envelope, which is ruptured to give the products liberty. The lorica indistinct in young beings.

Braun (*On Rejuvenescence, Ray Soc.* 1853, p. 158) appears to elevate this genus, in union with *Chlamydococcus* and *Glœococcus*, to the rank of a family parallel with the Volvocina, under the name of *Chlamydomonada*. Indeed, although, as Cohn has well shown, these genera agree in all essential particulars and relations with the Volvocina, yet the existence of each gonidium as an independent being contrasts so strongly with the aggregate condition of the rest of the Volvocina, that there seems sufficient ground to group them as a sub-family. In order, therefore, to retain the Chlamydomonada together, we shall depart from our usual custom, by inserting the new genera *Chlamydococcus* and *Glœococcus* after *Chlamydomonas*. *Chlamydomonas* was erroneously transferred, as before noticed, by Dujardin to the Thecamonadina, and renamed *Diselmis*. Its characters are thus discussed by Braun (*op. cit.* pp. 214, 215):—" *Chlamydomonas* is distinguished from the genus *Chlamydococcus* by the closely applied membrane of the old swarming-cells, also by the absence of the little starch-vesicles in the interior, while, however, as is usual in most of the Palmellaceæ, a single large chlorophyll utricle exists in the interior. There is no central red nucleus, as in the gonidia of *Chlamydococcus*; but some species have a parietal red spot. Motion is effected by two cilia, as in *Chlamydococcus*. As in that genus, there is a growth of the gonidia during swarming, which lasts over the day and night. There is also a formation of microgonidia," and a resting-stage in which the colour changes from green to yellowish red, or to red.

CHLAMYDOMONAS *Pulvisculus* (*Monas Pulvisculus*, M.)(XIX. 16).—Colour green; lorica oval; eye-speck brilliant red; filament double. (See *Diselmis viridis*, p. 512.) Cohn identifies it with *Polytoma Uvella*.

These creatures form a large portion of the green matter which colours the water contained in water-butts, ponds and puddles in the summer and autumn, and especially after a storm. They will rarely fail to be observed when any of this green water is examined under the microscope. Whenever these creatures exist in large quantities, multitudes of them and of their envelopes rise to the surface of the water, and form a green stratum upon it. Although this film somewhat resembles one of Ulvaceæ, yet it is easily distinguishable by its composition of living corpuscles with red specks, connected together by a loose mucous tissue, formed of dead specimens and empty loricæ. 1-550".

Kützing affirmed that this species was merely a phase of *Stygeoclinium*, into the filaments of which it became transformed by an act of germination. This opinion has not been accepted, as it is supposed that Kützing confounded the spores of that Alga with the gonidia of *Chlamydomonas Pulvisculus*.

Among the additional species of *Chlamydomonas*, those forms described by Dujardin as members of *Diselmis* (p. 512) should probably take their place here. Braun describes the following new species, premising the remark that "the species are doubtless very numerous, but the distinction of them from one another, as well as from the swarming cells of many other Algæ, is very difficult without a complete acquaintance with the history of their existence."

C. *obtusa* (Braun).—Colour dark green; truncate at both ends, and oblong, changing to spherical and a yellowish brown, and at length a red colour on assuming the resting-stage. "The macrogonidia grow during swarming, from 1-60th to almost 1-30th of a millimetre long; they are longish, of equal diameter on both sides, and very obtuse, almost truncated, having a colourless space at the ciliated extremity, presenting the form of a notch. The contents are dark green, finely granular, with a large vesicle at the posterior extremity, a roundish lighter space in front of this, and no red point. They multiply by simple or double halving in several successive generations. Sometimes a further continuation of the division of the full-grown macrogonidia occurs, forming 16 or 32 macrogonidia from 1-200th to 1-120th millimètre long, of ovate shape and lighter colour, tending towards brownish-yellow. The resting (seed-) cells are globular, about 1-40th millimètre in diameter, at first green, subsequently light yellowish-brown, finally flesh-red; they have a tough, colourless, and transparent membrane. In the Rhine valley, near Freiburg, in pools in sand-pits, which are occasionally almost completely dried up in summer."

C. *tingens* (Braun).—Gonidia smaller than in the preceding species, 1-120 to 1-60 millim. long, ovate, lighter green, likewise destitute of a red spot; the membrane is more distinct in old age. Increase by double, rarely by single halving; in the former case, by decussating sections. Contents granular, punctate in appearance, green, with one large vesicle. In the resting-stage they acquire a pale reddish colour; the vesicle becomes indistinct, and the contents coarsely granular in aspect from the formation of oil. Microgonidia also are formed. "The resting- but still green condition seemed to me to correspond to *Protococcus Felisii* (K.), that which turned red through desiccation, to *Pr. Orsinii*." In pools near Freiburg. Cohn (*Entwick.* pp. 202, 203) detected two vesicles in *Chlamydomonas*, below the point of insertion of the filaments, very slowly but rhythmically contractile, and mentions a species under the name of *Chlamydomonas hyalina*, which he makes synonymous with *Polytoma Uvella* (E.), and states to differ from *Ch. Pulvisculus* only by the want of chlorophyll and of a red speck (*op. cit.* pp. 140 & 169). He moreover notes a new form, probably generically distinct by having not a globular but a winged prismatic figure, quadrangular on a transverse section, with the two wings like two outstretched points, although in other respects agreeing with *Chlamydomonas Pulvisculus*. Perty (p. 85) objects to making *Chlamydomonas* a genus of Volvocina, and refers it instead to the so-called "Sporozoidia." He further tells us that *Chl. Pulvisculus* (E.) is rare about Bern, but there is a smaller form very common, which he proposes to call

C. *communis* (Perty).—He finds also, but less frequently, a more globular variety, which appears to be the *Trachelomonas emarginata* (Eichwald), but is in fact a *Chlamydomonas*, which he names

C. *globulosa* (Perty). — His species *Hysginum pluviale* and *H. nivale* (i. e. *Chlamydococcus*) he suggests uniting, with the species of *Chlamydomonas*, into a group (of Sporozoidia) under the name of *Schizonema*.

C. *multifilis* (Fresenius).—Round or oval; a distinct nucleus in the centre; granular contents green; filaments four, longer than the cell; at their base a rose-coloured contractile vesicle, and posteriorly to this a red stigma. Lorica thin, closely investing contents. As many as six filaments seen in some larger specimens. 1-92''' to 1-63'''. In fresh water.

C. *hyalina* (Cohn, Fresenius).—Elongated elliptical; rounded at both ends; filaments two, longer than the body; posterior half of cavity occupied by granules; a clear non-contractile space in the centre; a small contractile sac at the base of the filaments. 1-66''' to 1-46'''. In ponds coloured by *Euglenæ*.

It is doubtfully separable from *Chl. Pulvisculus*.

Genus CHLAMYDOCOCCUS (Part I. p. 148) (XIX. 20-31).—Gonidia spherical; colour green or red, enclosed by a hyaline structureless membrane, removed some distance from the coloured contents by a clear interspace or areola. The central protoplasm, coloured by chlorophyll or a red oil, and having one or more chlorophyll utricles at the centre, has its spherical figure destroyed by an elongation at one part into a tapering process, from which two filaments proceed, and, after perforating the external "envelope cell," protrude as motile vibratile organs. The inner, coloured globule has no special membrane, and in consequence undergoes multiform transformations of its outline in the course of development. In the resting-stage the enclosed coloured mass, the "primordial cell," secretes over its surface, inside its envelope cell, a new, tough, cellulose membrane, whilst the envelope cell is dissolved into a mucous layer. In such still cells macrogonidia are produced by fission of the contents, in the power of two, and after a time burst through the parent cell, develope their two ciliary filaments, and proceed to develope a cellulose membrane over their entire surface, which becomes further and further removed until they acquire the characters of the ordinary moving cells. When division is more frequently repeated, microgonidia are formed, which move much more actively, and do not secrete an envelope cell; they are incapable of propagation, and pass immediately into the condition of rest. The motionless cells of *Chlamydococcus* are of much simpler structure than the motile, and consist simply of a tough, spherical, cellulose membrane, and green or red contents, organized as a primordial utricle. Vacuoles are found among the contents of *Chlamydococcus*-cells; but a contractile vesicle has escaped observation. *Chlamydococcus* and the two allied genera, *Glœococcus* and *Chlamydomonas*, differ from the true Volvocineæ in this respect: viz. they separate from each other after complete fission, as primordial utricles, and then severally proceed to form an independent envelope cell; whilst the rest of the Volvocineæ continue, on their production by fission, to live in groups and produce around their aggregated mass an envelope cell in common. It bears the same relation, therefore, to the rest of the Volvocineæ that *Pleurococcus* does to *Palmella*, *Cyclotella* to *Meloseira*, or *Vorticella* to *Epistylis*. *Chlamydococcus* is distinguished from the moving germs (sporozoids) by which the greater number of Algæ propagate, both by a somewhat more complex structure, and by the circumstance that the motion lasts for a very long time, and, finally, by the power of the moving cells to propagate as such, without entering into the state of rest otherwise than as quite a temporary condition. Perty, who has studied this genus very minutely, employs the term *Hysginum* to designate it, although it had previously received other names from other observers, besides that we have employed. Indeed, owing to the various appellations given, and especially the specific names invented for the multiform varieties of the same organism, the synonyms became very perplexing and a positive impediment to the progress of our knowledge of this genus. Among the multitude of proposed species, two only are now accepted, viz. *Chlamydococcus pluvialis* and *Chl. nivalis*; but their distinctive characters are nowhere detailed in a definite and available form for our purpose. The red snow of Alpine regions is the red variety of both these species. The other varieties of *Chlamydococcus* have been more widely described under the title of *Protococcus*, and those of a red colour under that of *Hæmatococcus*. Cohn cites two principal synonyms for *Chl. pluvialis*, viz. *Hæmatococcus pluvialis* and *Chlamydococcus versatilis*, and in his Monograph on this organism employs the term *Protococcus pluvialis*, although in a subsequent contribution he adopts Braun's designation as employed by us. The many modifications of form of this one species under different circumstances of development and habitat have received as many different names, from the notion of their being specifically distinct. These Cohn has pointed out in his essay; but only that portion of them is worth citing which has attracted notice in various works. "Thus the still *Protococcus*-cell corresponds to the *P. Coccoma* (Kütz.): when the border becomes gelatinous, it resembles *P. pulcher*, and the small cells *P. minor*. The encysted motile zoospore, on the other hand, is the *Gyges Granulum*, and resembles also *P. turgidus* (K.) and perhaps *P. versatilis* (Braun). The zoospores divided into two must be regarded as a form of *Gyges bipartitus*, or of *P. dimidiatus*." A red variety of the cell was described by Girod Chantrans as a *Volvox*, under the name of *Volvox lacustris*; but Perty refers it to *Hæmatococcus*.

CHLAMYDOCOCCUS *pluvialis*.—Sufficiently characterized in the above history.
CHL. *nivalis*.—Unsatisfactorily distinguished.

Genus GLŒOCOCCUS.—This is a new genus suggested by Braun (*On Rejuvenescence*, p. 159), who thus describes it:—"Ovate, green cells, with a colourless point, from which a funnel-shaped, lighter space extends inwards; a rather large vesicle also is formed at the posterior extremity. Multiplication by simple or double, in the latter case decussating fission, after which the cells remain loosely connected together by the secretion of soft, gelatinous, confluent coats, forming globular and finally amorphous families (clusters). The cells of all the generations succeeding each other during the formation of these families (excepting the transitory cells in the case of double halving) are provided with two very long persistent cilia, which disappear only when division commences. The cells exhibit a feeble motion inside the enveloping and connecting jelly, the anterior end jerking in and out, or suddenly retracting a little. The last generation of the family leave the gelatinous mass, and swarm out, to settle down quickly in some other place. It is probable that the formation of a new family is preceded by a rather long state of rest—perhaps there are several resting generations; but we have no observation on this point." A red speck is not perceptible. Two species are named:—

GLŒOCOCCUS *mucosus*.—The full-grown cells are 1-60 to 1-50 millim. long: the clusters, forming at the bottom of little ponds, attain the size of an apple, and are of compressed globular, often lobed-shaped form; but at length they break up, and come to the surface of the water in irregular fragments. The gelatinous mass has a peculiar greenish spotted aspect, which depends upon subordinate groups of generations being more closely packed together.

G. *minor*.—Perhaps specifically distinct. Appears in the springs at Freiburg early in the year, in the form of light-yellowish-green, often pear-shaped "stocks" (masses), almost as large as a hazel nut, attached to the sides of the gutters of the springs, finally becoming detached, swimming, and shapeless. The cells are somewhat small, 1-100 to 1-75 millim. long.

Genus SPHÆROSIRA.—Tail-like process absent; eye-speck and filament single. Self-division, unlike that in the preceding genera, occurs unequally within the envelope, and forms young clusters at once from the parent ones. This genus differs from *Pandorina* in having the eye-speck, from *Eudorina* by its unequal mode of self-division, and from *Volvox* by its simple filament. Self-division in these creatures takes place in the longitudinal direction, in parallel planes; so that laminæ are produced, as in the case of *Gonium*.

Sphærosira, as heretofore remarked, is regarded by Prof. Busk as a doubtful independent organism; he is, however, unable to speak positively on this point, and therefore, whilst still keeping it distinct from *Volvox Globator*, of which he had some reason to suppose it a peculiar mode of development, ranks it as only a species of *Volvox*, instead of elevating it to the rank of a genus, and calls it *Volvox Sphærosira.* Dujardin also denied the distinction drawn by Ehrenberg between *Sphærosira* and *Volvox*, but did so from mistaken views; for he represented *Volvox* to have only a single filament, whereas both this and *Sphærosira* have two. "It presents the appearance," says Mr. Busk (*M. T.* 1852, p. 33), "of a transparent globe, set with green spots, but it differs from the ordinary varieties of *Volvox Globator* in two important respects: 1, in the absence of any internal globules or embryos; 2, in the irregular size of the green granules lining the wall which, instead of being of uniform size, are of various dimensions. The different-sized granules are irregularly disposed, although, in relation to the sphere itself, they, or rather the centres of them, are as regularly distributed as in the three just-described forms (of *Volvox*). What is rather remarkable with respect to this form is the circumstance that the larger granules are not disposed over the whole periphery of the sphere, rarely occupying more than two-thirds of it towards one side." Again, he adds—"The smaller ones appear to resemble in all respects those of *Volvox Globator*, and each to possess two cilia, which is important, if true, because the only distinction between *Volvox* and *Sphærosira* in Ehrenberg's classification depends upon the circumstance that in *Sphærosira* there is only one cilium to each zoospore, whilst there are two in *Volvox*.

"My supposition that *S. Voluox* and *V. Globator* are allied is founded, it must be owned, not upon any direct observation, but chiefly on the fact that in the water in which the specimens of *Volvox* were contained there were at first none of *Sphærosira*, any more than of *V. aureus*, and that after some days both were very numerous. The difference I am about to describe in the after-development of the ciliated zoospores is not by any means a sufficient ground upon which they should be deemed distinct species, because much greater differences are known to exist in other of the lower Algæ during their various forms of development, without it being thence allowable to suppose that they are of different species. In *Volvox Sphærosira*, then, as at all events it may be termed, the larger green granules are in fact the ciliated zoospores in a state of further progressive development. In the same specimen they will be seen in all states of division or segmentation,—first into two, then into four, and so on, till, as in the case of the embryo *Volvox*, the ultimate result of the segmentation constitutes numerous minute ciliated cells or bodies, not, however, as in that case, lining the inner surface of the wall of a spherical case, but forming by their aggregation a discoid body in which the separate fusiform cells are connected together at one end, and at the other are free, and furnished each with a single cilium. In this stage their compound masses become free and swim about in the water, constituting, in fact, a species of the genus *Uvella*, or of *Syncrypta* of Ehrenberg."

Mr. Carter affirms (*A.N.H.* 1859, iii. p. 4) that *Sphærosira* is not a distinct genus, but the "spermatic form" of *Volvox Globator*, which he describes as one phase of development of this species, wherein upwards of a hundred of the gonidia, scattered over the periphery of the primary gemmæ of the parent globe, divide repeatedly until they are broken up "into 128 (?) linear ciliated segments, which are ultimately arranged vertically upon the same plane, in a circular tabular group, with their cilia upwards; and when the latter are sufficiently developed, the group oscillates and rotates by their aid both upon its long and short axis. These segments are, in fact, the spermatozoids, each of which, when they separate, is observed to be linear, horn-shaped, and colourless anteriorly (where it is attenuated), and greenish posteriorly, provided with a pair of cilia which are attached to the anterior extremity, and some distance behind them with an eye-spot; their progression is vermicular from their extreme plasticity, and they keep up an incessant flagellating movement with their cilia. As yet, I have never seen any of these free in the daughter bearing the spermatic cells when the former has been *outside* the parent; nor have I ever seen them free under any circumstances, except once, in the old *Volvox*, when the daughter containing the spermatic cells from which they had been developed had been partly eaten up by Rotatoria.

"This is the form of *Volvox Globator* which has been called *Sphærosira Volvox* by Ehrenberg; and, like the daughters bearing the spore-cells, it becomes liberated from the parent before the spermatic cells attain their ultimate development, that is, before the groups of spermatozoids become separated, not before they are formed. It is worthy of remark, too, that the daughter bearing spermatic cells is never more than half the size of the spore-bearing daughter, at least as far as my observations extend.

"Thus we have the spore-cells and the spermatic cells in *different* daughters; and as I have never seen them together in the same daughter, nor the daughters respectively bearing them in the same parent *Volvox*, out of some scores of instances, I can come to no other conclusion than that the two daughters meet after they have left their respective parents, when, both the spores and the spermatozoids having become ripe for fecundation, individuals forming the groups of the latter separate, burst from their capsules into the cavity of the daughter, and from thence find their way out into the water, and then into the cavity of the daughter bearing the spore-cells, where they become incorporated with the latter.

"Hence *Volvox Globator* would appear to be diœcious, and not monœcious as stated by Cohn; and *Sphærosira Volvox* not, strictly speaking, another form of *Volvox Globator*, but the spermatic form. Cohn, considering *Volvox Globator* and *Volvox stellatus* the same species, has taken his fecundating character from the spermatic form of the latter."

The spermatic groups above described, Carter subsequently remarks, constitute in all probability Ehrenberg's genera *Syncrypta*, *Synura*, and *Uroglena*.

SPHÆROSIRA *Volvox*. — Corpuscles pale green, of nearly a globular shape, enveloped in a common mantle. Eye bright red. The cluster resembles a great ball of corpuscles, containing small compressed clusters within it. Found in considerable numbers in company with *Volvox Globator*, and often attains its size. Sometimes found by itself.

Genus VOLVOX (XX. 32–47) (Part I. p. 180).—The genus *Volvox*, which is the type of the family Volvocina, was instituted by Linnæus, and promulgated to the world in 1758, in the tenth edition of his 'Systema Naturæ.' As first described by him, the two species *V. Globator* and *V. Chaos* comprehended all known Infusoria, excepting eleven of the tribe *Vorticella*, which were separated from them, under the denomination of *Hydra*. In his twelfth edition (1766) of the same work, he distributed the Infusoria into four genera, viz. *Vorticella*, *Volvox*, *Hydra*, and *Chaos*.

Volvox is characterized by the aggregation of its cells or gonidia over the internal surface of a transparent lorica or common envelope cell, of the form of a hollow globe. Each corpuscle or gonidium possesses a red speck and two filaments, which protrude beyond the surface of the lorica so as to give the whole globe the appearance of being covered with cilia. The mode of increasing by a sort of internal gemmation is characteristic of the genus.

Dujardin was unable to detect more than one filament; but Ehrenberg's description of two is now amply corroborated.

The structure of *Volvox* has received the careful study of many eminent microscopists, who have been compelled to differ largely from Ehrenberg in their accounts of it. The résumé given in the general history of Phytozoa renders it perfectly unnecessary to repeat in this place the particulars of the organization of the members of this genus or to enter into the discussion respecting their true nature as organic beings.

VOLVOX *Globator* (M.) (xx. 32–47) (p. 180 *et seq.*).—So called from the globular figure of the aggregate mass or colony constituted by the individual monadiform beings or gonidia. When blue or red colouring matter is mixed with the water, strong currents may be observed under the microscope around each globe, which, when in motion, always proceeds with the same part foremost. xx. 32 represents a large globe with eight smaller ones (termed by Ehrenberg, sisters) within it. xx. 34 is a section of a globe, more magnified. xx. 35 represents three gonidia *in situ* within the common envelope. In shallow pools of clear water, in spring and summer. The largest globes measure 1-30″ in diameter; the smallest free swimming ones 1-360″ to 1-240″. Size of a single corpuscle 1-3500″.

Ehrenberg notified the peculiar occurrence of living Rotatoria within the globes of the *Volvox Globator*. Mr. John Williams has communicated (*T. M. S.* 1851, iii.) an interesting observation, confirming Ehrenberg's account.

Within the cavity of a large specimen of this species, evidencing its usual vitality, and the ciliary movements on its surface, he noticed a very active Rotifer, which he believes to have been the *Notommata parasitica*, and which was subsequently accompanied by another of the same species, but smaller. He adds, "By the most careful examination, no opening could be perceived by which they could have been introduced; neither did there appear to have been any viscera by which their motions might be impeded, as they swam about as freely as fish in a glass globe, to which, indeed, they bore no faint resemblance."

The two following species, named *V. aureus* and *V. stellatus*, are, in the opinion of Profs. Busk, Williamson, and Perty, merely developmental phases of *V. Globator*—*V. stellatus* being the later stage. "*V. aureus*" says the writer first named (*op. cit.* p. 32), "exhibits precisely the same structure as *V. Globator*, the only apparent difference between them consisting in the deeper green colour of the internal globes. These, however, soon exhibit a more important distinctive character, in the formation of a distinct cell-well of considerable thickness around the dark-green globular mass. This wall becomes more and more distinct; and after a time the contents change from dark green into a deep orange-yellow, and simultaneously with this change of colour the wall of the globule acquires increased thickness, and appears double.

"The third form, or *V. stellatus*, differs in no respect from the two former, except in the form of the internal globules, which exhibit a stellate aspect, caused by the projection on their surface of numerous conical eminences formed of the hyaline substance of the outer wall. The deep colour of the contents of their embryos, and their change into an orange colour, at once point out their close analogy with those of *V. aureus*. I have no doubt of their being mere modifications of the latter, and I have observed smooth and stellate globules in the interior of one and the same parent globe."

Mr. Carter, however, does not share this opinion with reference to *V. stellatus*, which he treats (*A. N. H.* 1859, iii. p. 5) as a distinct species.

These extracts from recent and well-known authorities are further valuable as supplying an explanation of Laurent's statements that two sorts of reproductive bodies appear in the globes of *Volvox*. Little weight is attached to this gentleman's microscopical researches, which are mostly ideal.

V. *aureus*.—Green, nearly globular. The small secondary globes within them are of a golden colour, and smooth surface. In rain-water standing on turf. Diam. of globe 1-30″.

V. stellatus.—Small, subglobose, sometimes oblong, or of an angular form, and green colour. The contained globes within them are of a green colour, and have their surfaces tuberculated or stellated. Diam. of globe 1-30″.

Carter, who accepts this species, describes it in the following words, using the quaint terms "daughters" and "grand-daughters" for the "primary" and "secondary" generations or gemmæ of the parent globe of the *Volvox*:—"*Adult form.*—Globular, slightly ovoid, consisting of three generations or families within one another; containing generally eight daughters, in each of which there are generally eight grand-daughters *indistinctly* visible. Daughters confined to the posterior three-fourths of the spheroid, the anterior fourth being empty. Progressing with the empty end forwards. Daughters rotating (this marks the adult form here also) in their capsules respectively, which are fixed to the internal periphery of the parent. Grand-daughters small and indistinct, motionless, and fixed to the internal periphery of the daughters respectively. Peripheral cells conical and biciliated, not uniciliated as figured by Ehrenberg. 59-1880″ long and 54-1880″ broad."

In his subsequent remarks, he makes it the specific point of difference between the primary gemmæ of this *V. stellatus* and *V. Globator*, that those of the former begin to undergo duplicative subdivision almost immediately after they appear, or "at the time when they do not exceed three times the diameter of the peripheral cells," or 1-2700″, instead of "not passing (as in *V. Globator*) into small cells until they have arrived at more than the 1-300″ in diameter." He also alludes to differences between these two species in the form of the spermatozoids and the mode of fecundation. We venture to remark that if these latter particulars are sufficient to indicate specific differences, it is not so with the size of vegetable cells at which fission may commence. The history of all the simplest cellular organisms we know of shows that the period of cell-life, and therefore the dimensions of the cells at which it occurs, stands in no constant relation with the act of fission. The size of a cell and the proclivity to fission depend much on external conditions affecting its vital activity.

The following genera are distinguished by Perty:—

Genus SYNAPHIA (Perty).—Corpuscles from 10 to 12, aggregated together within a spherical gelatinous envelope, in mutual contact, so as to form a compact mass. The corpuscles, each furnished with a single filament, are not spherical but angular and wedge- or pear-shaped, with the wide end turned towards the pheriphery. In very exceptional specimens the gonidia are somewhat separated from each other. Length of filament equal to, or 1½ the diameter of the corpuscle, and very fine. The relation between *Gonium* and *Pediastrum* has been noted by Cohn and other observers; but that between this newly-constituted genus of Perty and the second-named group is much more striking, whether the description given or the illustrative figures be considered; indeed the impression forces itself upon us, that *Synaphia* is simply a form of *Pediastrum*. This impression is moreover strengthened by the fact mentioned by Perty, that the movement of the organism, and the fine filament, disappear as the organism advances in age and dimensions.

SYNAPHIA *Dujardinii* (Perty).—Corpuscles clear green to dark or blackish green, measuring within the enclosing envelope 1-1300″ to 1-360″, more commonly from 1-720″ to 1-480″. Movements torpid or tolerably quick, around one or other axis, always oscillating. The filaments are only visible when the spherical colony is at rest. The radiating grouping of the individual gonidia is not completely symmetrical; sometimes the spherical figure is exchanged for an ellipsoid. The gelatinous envelope varies in breadth, is clear and translucent, rarely having a red blush under the microscope, and, in large specimens, frequently divided by fine lines into two or three halos. When dying, the several corpuscles detach themselves, and after death do not undergo diffluence, but turn yellow and ultimately dissolve away. Frequently a green granule is visible internally, and a scarcely-discernible red point.

Genus HIRMIDIUM (XIX. 15) (Perty).—A chain of from 4 to 8, very small rounded corpuscles of a pale green colour, surrounded by a gelatinous envelope. This genus appears to us very erroneously referred to the Volvocina; but the figures given are not sufficient to determine to what family they more rightly belong.

HIRMIDIUM *inane* (XIX. 15).—Corpuscles irregularly spherical, almost cup-shaped, and probably furnished each with two filaments. Some very fine molecules, one generally of a hark hue, perceptible internally. The chain advances quickly by revolving on its long axis; gelatinous; common envelope inconspicuous. Length of chain 1-360"; size of individual corpuscles 1-1900". From its smallness, this organism is difficult of observation, and requires further investigation. Only in small numbers, in some ponds in the canton of Bern.

Werneck characterized several new genera, which he referred to the Polygastrica of Ehrenberg (*Monatsb. der Berl. Akad.* 1841, p. 377), two of which are to be inserted in this family, as allies of *Pandorina*, and are very briefly characterized under the names of *Calia* and *Stephanoma*:—

CALIA.—Monads imbedded in a gelatinous mass, affixed to plants, and not swimming freely about. Two species are known; the characters not given. This genus is very probably nothing more than one of the simple Algæ.

STEPHANOMA=*Pandorina* with a single zone of corpuscles, which divide like the cells of *Gonium*. One species observed exhibiting a circlet of spherules united to form a wreath or zone. This genus is probably the same as *Stephanosphæra* (Cohn, *A. N. H.* 1852, p. 407).

Genus STEPHANOSPHÆRA (Cohn) (XIX. 38–58).—A family of cells, rotating and moving throughout life; composed of *eight* green primordial cells, each bearing *two* active cilia; arranged at equal distances in a *circle*, enclosed in a common hyaline *globose* vesicle, or common envelope; propagated both by *macrogonidia* (originating from *eightfold* division of each of the green cells), which bear two cilia, and are congregated into eight octonary families, and by *very numerous* smaller *microgonidia* (produced by *multifold* division), revolving at first within the common vesicle by the action of *four cilia*, and then escaping singly.

STEPHANOSPHÆRA *pluvialis*.—Green, cells globose, elliptical, or fusiform, often running out into mucous rays at both ends. Diameter of the cells = 1-330th to 1-180th of a line (0·0065 to 0·012 mm.); diameter of common vesicle = 1-80th to 1-40th of a line (0·028 to 0·055 mm.). Revives after desiccation. Inhabits hollow stones filled with rain-water, in company with *Chlamydococcus pluvialis*: Salzburg, *Werneck*?; Zamora, *A. von Frantzius*; Hirschberg, *Von Flotow*.

Dr. Strethill Wright has met with *Stephanosphæra* in Scotland.

FAMILY V.—VIBRIONIA (see p. 184).

(XVIII. 57–69.)

ACCORDING to Ehrenberg, the members of this family are distinctly or apparently polygastric, but without a true alimentary canal; have neither appendages nor lorica, and are incapable of changing the form of their body. They are linked together in thread-like chains, formed by their imperfect transverse self-division. Information respecting the Vibrionia is very imperfect; this is attributable to the exceeding minuteness of the individual animalcules which compose the chains. These last have never any determinate length, or number of component corpuscles, and they are sometimes so short as to be made up of not more than two or three individuals, which are only distinguishable from *Monas Termo* and *M. Crepusculum* by their union in chains, and by their peculiar, though not easily characterized movements. The motion of the chains is generally of a writhing character. In one genus

(*Bacterium*), a single vibratory filament is present. In this same genus the individuals are strung more tightly together, so that the filiform cluster, not being able to exert the writhing movement seen in the true Vibrionia, moves rigidly in a direct course. In *Spirillum* the articulations or lines of imperfect fission are oblique; hence increase in length by division engenders a spiral chain.

The animals of this family, says Dujardin, "are the first Infusoria which present themselves in all infusions, and those which from their extreme smallness and the imperfection of our means of observation must be considered the most simple; .... and it is only their more or less active movements which lead to their being regarded as animals. I have been sometimes induced to believe that a flagelliform filament, analogous to that of Monads, or rather a spiral undulating one, exists, and that this is the cause of the peculiar mode of locomotion. Is the *Bacterium triloculare*, described by Ehrenberg as having a proboscis, a true Vibrio?

"All that can be with certainty predicted respecting their organization is that they are contractile, and propagate by spontaneous fission, often imperfect, and hence giving rise to chains of greater or less length."

As stated in our general history of the family (p. 184), the present tendency among naturalists is to refer Vibrionia to the vegetable kingdom. Cohn assigns them a place in the family Mycophyceæ among the microscopic aquatic Fungi. Perty retains them in his group Phytozoida, expressing at the same time his conviction that they are of a vegetable nature. Indeed the only reasons advanced by Ehrenberg in support of the animality of Vibrionia are, that they are actively, and, to his apprehension, voluntarily moving beings, and multiply by self-division,—reasons which, in the present state of knowledge, must be held worthless. A re-examination of all the enumerated species, as Cohn remarks, is imperatively necessary before we can come to any safe conclusions relative to the true structure and affinities of the Vibrionia; and this same able observer has himself set the example by conducting such an examination of one species as to clearly indicate its physiological characters and its relation to *Palmella* and *Tetraspora* among the Algæ, and more particularly to *Sphærotilus* among Mycophyceæ.

The Vibrionia are developed with extreme rapidity in all liquids containing changed or decomposed organic substances, in animal fluids—the saliva, serum, urine, &c. When colouring matter has been mingled with the water, its imbibition by the corpuscles has never been observed.

This family is distributed by Ehrenberg as follows:—

Articulated threads (clusters) straight, the transverse divisions being rectangular	Inflexible		Bacterium.
	Flexible, like a snake		Vibrio.
Articulated threads spirally twisted (like a bell-spring or cork-screw), the transverse divisions being oblique	Flexible		Spirochæta.
	Inflexible...	with a cylindrically-extended spiral form.	Spirillum.
		with a compressed spiral form	Spirodiscus.

On this subdivision of the family Vibrionia, Cohn (*Entw.* p. 117) has expressed himself very strongly. He says, "An inextricable confusion prevails when specific characteristics are attempted: we have the observations, good and bad, of various authors, weak and strong amplification of the objects, young and old conditions commingled without any critical endeavour to distinguish between them." Feeling that there is no sufficient basis for it, Cohn does not attempt a classification of the Vibrionia. The *Monas Lineola*

(E.) or *Bacterium Termo* (Duj.) is, according to his well-conducted investigations, no other than the swarming stage of a microscopic aquatic fungus belonging to the Mycophyceæ, of which he makes a new genus, named *Zooglæa*: again, *Spirochæta plicatilis* is, in his opinion, an Alga of the genus *Spirulina*, and the stiff Vibrios allies at least of the Oscillariæa, of the genus *Beggiatoa*; the shorter Vibrios and *Spirilla* likewise resemble Oscillariæa and *Spirulina*.

Should Cohn's opinions be confirmed, the Vibrionia, as a distinct family, would be well nigh broken up. In fact, his views are generally acceded to; for Perty, Burnett, and others all point out their peculiar affinities with the Oscillariæ, and discover similar forms among the transitional phases of various Algæ, and, indeed, among the antheridial spores of higher plants. The value of *Spirodiscus* as a genus is little insisted upon by Ehrenberg, who instituted it; and in all probability it should be set aside, and *Spirochæta* also be sacrificed with it. The only species of *Spirodiscus* named, Perty surmises, might have been nothing more than the spore of a fungus. Dr. Burnett has expressed himself as follows to the same effect; for he observes, "When we come to organisms as minute as these, the distinguishing characteristics of genera and species become too obscure and equivocal to have much value; and the best microscopists have arrived at the conclusion that such distinctions are too refined and will not bear the test of experience.

"The genus *Vibrio*—the simplest—I regard as the first appearance of the young Alga, existing then as the smallest cells, arranged in linear series. The genera *Spirillum* and *Bacterium*, composed of larger forms, and of a finer and more solid structure, represent the more advanced forms; and as all Algæ, as they advance in size, tend to consolidate into mycodermous forms, losing much of their primitive cell-structure, so these two genera appear to have lost their old beaded type. As for the two remaining genera, *Spirochæta* and *Spirodiscus*, but little is positively known. They scarcely appear to belong to the other forms of this family; and as Ehrenberg himself has expressed a doubt upon the subject, one may as well omit a further notice. Therefore, in a structural point of view, the species of this family seem to be only Algæ at different stages of growth."

Dujardin instituted only three genera of Vibrionia, viz.: 1. *Bacterium*—straight, slightly flexible threads, more or less distinctly jointed, and slow in their movements; 2. *Vibrio*—either straight or flexuose, with a more or less vivacious writhing movement; 3. *Spirillum*—having the form of a corkscrew, revolving on their long axis, oftentimes with great rapidity, but never straight. Perty has made a more ambitious attempt to classify these minute organisms; of its utility, however, little can be said, for our acquaintance with them is too imperfect to establish satisfactorily any distribution of them. To resume: Perty makes a section of his heterogeneous group Phytozoida, which he calls *Lampozoidia*, represented by the one family "Vibrionida." The "*Lampozoidia*" are defined as "colourless, or rarely blue, yellow, or red, never green, organisms, without special organs, and with scarcely a trace of differentiation of substance. Their motions, though seemingly voluntary, are in fact only automatic. They multiply by transverse fission, and in so doing produce chains and fibres." Of the family Vibrionida, two varieties are distinguishable:—A. *Spirillina*, in which the chain or fibre is spirally coiled; B. *Bacterina*, in which it is contorted or straight. Spirillina contains two genera, *Spirochæta* and *Spirillum*; whilst Bacterina is made up of four, viz. *Vibrio*, *Bacterium*, *Metallacter*, and *Sporonema*. The new genera named will follow after our account of those recognized by Ehrenberg, and the notes on the others in their proper places.

Genus BACTERIUM.—Vibrionia distinguished by the corpuscles being connected together in a thread-like more or less rigid or inflexible chain, and by multiplying by transverse self-division at right angles to the chain.

The three species known are colourless, and extremely minute. Ehrenberg remarks "that only one of the species has been satisfactorily determined, and that their organic relations are altogether so obscure, that our judgment respecting them must unavoidably be left in a fluctuating state." In *B. triloculare* a vibratory proboscis, a granular mass within the body of the creature, and spontaneous division are discoverable. All the species enjoy an active power of locomotion. Perty says that he is unacquainted with the species of *Bacterium* enumerated by Ehrenberg.

A magnifying power below 500 diameters will not exhibit the divisions or transverse lines between the individuals or links of the wand or chain. *Bacterium* occurs around decomposed vegetable matter, on the surface of water containing Chara, &c.

BACTERIUM *triloculare*. — Chain in the form of short cylinders of from two to five oval corpuscles, and generally about three times as long as their diameter; transverse junction-lines distinct. Ehrenberg has observed not more than five links together, nor less than two. "By throwing," he adds, "a little colouring matter into the water, an evident vibration may be perceived near the anterior portion of the corpuscle or of the chain; and upon a very close inspection a simple filiform, though short, proboscis may be seen, which, in the larger specimens, is one-third the length of the body, and in the smaller, one-half." The motion of this creature is tremulous, or slowly revolving upon its longitudinal axis. In the water of bogs. Length of chain 1-4800" to 1-2304"; single corpuscle 1-11520" (XVIII. 57). Group 57 represents several of them; two towards the right are magnified 1000, the others 290 diameters.

B. *Enchelys*. — Chain composed of somewhat indistinct, colourless, oval corpuscles united in smaller cylinders than the preceding; transverse lines faintly marked. In river water. Length of chain 1-2880".

B. *Punctum*.—Chain cylindrical, composed of indistinct, colourless, globose corpuscles; much smaller than the preceding species; transverse lines faintly marked. In water wherein bread has been steeped. Length of chain 1-4032".

B. *Catenula* (D.).—Filiform, cylindrical. Length of individuals 1-8600" to 1-6500"; 3, 4, or 5 are united together, forming a chain 1-1300" in length.

Genus VIBRIO.—Characterized by the corpuscles being connected together, through incomplete self-division, in filiform flexible chains resembling in miniature the figure and movements of a snake. Junction-lines at right angles to chain.

VIBRIO *Lineola* (*Bacterium Termo*, Duj.) (XVIII. 69). — Forms a minute cylindrical and slightly flexible wand, rounded at both ends; separate corpuscles somewhat indistinct, of nearly globular form, and colourless. Common in vegetable infusions, especially around the stalks of flowers in glasses, and in foul ponds. Length of wand, from 1-3600" to 1-200". Thickness 1-3600". Both Cohn and Perty join in the use of Dujardin's name for this species, and in representing Ehrenberg as in error in identifying and fixing its characters (see genus ZOOGLŒA).

V. *tremulans*.—Wand short; stouter, yet more flexible, than the preceding; articulations of an oblong form, not distinct. In water emitting a disagreeable odour. Length of wand 1-3600".

V. *subtilis*.—Wand slender and elongated; colourless; articulations distinct; motion slightly vibrating, without varying the direct position of the articulations. Length 1-450"; thickness 1-24000". Perty says this species is only a variety of *V.* (*Metallacter*) *Bacillus*.

V. *Rugula* (*Vibrio Rugula*, M.) (XVIII. 64).—Wand elongated; stouter than the preceding; articulations distinct; and colourless; motion brisk and serpentine; common in infusions and foul water. Length 1-580"; thickness 1-12000".

V. *prolifer*.—Wand short, stout, and colourless; articulations distinct. Motion slow and tortuous. In infusions where mildew is present. 1-1100".

V. *Bacillus* (M.) = *Metallacter Bacillus*

(Perty).—Wand stout, elongated, and transparent; articulations distinct, or become so when dried; motion serpentine; form straight when quiescent (XVIII. 62). In vegetable infusions and fetid water. Length 1-200″; thickness 1-17200″.

V. *synxanthus.*—Wands (bacilli) very fine and short, rather flexuose, rarely, of more than five segments (individuals), yellow and minute. Corpuscles 1-70000″ to 1-52000″. In decomposing cow's-milk, in which it produces a yellow tint.

V. *syncyanus.*—Wands very slender and short, somewhat flexuose, of seldom more than five segments, very small, and of a blue colour. 1-78000″ to 1-52000″. Also found in cow's-milk, in which it produces a decided blue shade.

The following species are from Dujardin's work:—

V. *serpens* (M.).—Body very long, filiform, undulating, generally pursuing a rectilinear course, with from ten to fifteen bends in its length. 1-1050″.

V. *ambiguus.*—Under this name, Dujardin describes a *Vibrio* with stiff filiform joints like those of *V. Bacillus*, but much larger (XVIII. 60). Four or five, or even more, were articulated together; owing to the large dimensions, each joint could be seen composed of a resistant tube, in which a glutinous substance was more or less closely packed. Moreover, a bifurcation at the extremity of a joint was sometimes seen to occur, giving rise to two rows of branching chains, of more or less length.

Such observations tend to render the animality doubtful, not only of this *Vibrio*, but also of the similar but smaller *V. Bacillus.*

Genus SPIROCHÆTA.—Chains spiral, filiform and flexible, lengthening by the imperfect or incomplete mode of self-division. The details of organization are at present unknown. Dujardin does not admit this as a genus distinguishable from *Spirillum*; and Cohn is unable to discover any sufficiently distinctive characters between this and the acknowledged vegetable genus *Spirulina*. *Spirochæta* moves with an immense activity, surpassing what is observed in the recognized species of *Spirulina*; but this difference is not sufficient to separate the two generically. *Spirulina plicatilis* is figured (XVIII. 67, 68). Cohn moreover inclines to the opinion that *Spirulina*, *Spirochæta*, and *Spirillum* are members of one common group of organisms of a vegetable nature. The distinctive feature between *Spirillum* and *Spirulina* is the small number of corpuscles found united in the chains of the former compared with the latter.

Spirochæta *plicatilis* (*Vibrio serpens*, M.) (XVIII. 63).—Corpuscles very delicate, nearly globular, connected together in a long, filiform, spiral chain, having numerous and closely-arranged coils; colourless. At Tilbury Fort. Length of chain 1-170″ to 1-440″; thickness 1-12000.″

Genus SPIRILLUM.—Developes in the form of tortuous chains, or of inflexible and cylindrical spirals. The incomplete self-division, which is oblique in direction, produces the characteristic coiling of the chain. Motion brisk and energetic.

Spirillum *tenue*.—Spiral of three or four coils, constituted of very slender, slightly bent colourless fibres; articulations distinct. In vegetable infusions. Length about 1-900″; thickness 1-1200″.

S. *Undula* (*Vibrio Undula*, M.) (XVIII. 59-61).—Spiral of one turn and a-half; corpuscles short, stout, and much bent; articulations distinct; colourless; when dry, the articulations are more distinct. In stagnant water having a mildew scent. Length about 1-1500″; thickness 1-20000″. This species, Perty remarks, frequently grows so as to form clusters or masses which are motionless, and, like all the rest of the Vibrionia, never produces true vegetable fibres.

S. *volutans* (*Vibrio Spirillum*, M.).—Of three, four, or more coils; fibres very tortuous, long, and stout; articulations distinct; colourless. In vegetable infusions. Length of spiral 1-2200″ to 1-500″; thickness 1-14400″.

Perty adds the following species:—

S. *rufum*.—Has the figure and size of *S. Undula*, but is of a red colour. No articulation discoverable. In pond-water about Bern, which had been kept several weeks. The claim of this to be considered a distinct species is highly doubtful; for its only assumed characteristic, viz. its red colour, is of no weight, being in the Phytozoa generally a variable condition, due to chemico-vital changes in the organisms, and ephemeral in duration.

S. (?) *Bryozoon* (Unger) (XVII. 520–531).—Coils consist of a thick body, with a delicate, wavy, hair-like proboscis. These creatures, found in the reproductive organs of plants, were called by their discoverer, Dr. Unger of Gratz, spermatic animalcules, and are described in detail in the *Regensburger Botan. Flora*, 1834; and also in the 18th vol. of the *Nova Acta Nat. Cur.*, Bonn, 1838. A condensed view of this subject is given by Dr. Meyen in the *Jahresbericht* for 1838, from which the appended translation is made. The accompanying illustrations (XVII. 520–531) were kindly supplied by Dr. Unger for this work.

"The spermatic animalcules in *Sphagnum* consist, according to the earlier observations of Unger, of a thick body, and a thin filiform tail; when in motion, this tail being anterior, he considers it analogous to the proboscis (filament) of many of the Infusoria. No true active motion of the body itself has been observed by Unger; but he distinguishes between the mere locomotive and the rotary movements of the whole animalcule. The simplest motion takes place in a spiral direction; and if the proboscis is contracted, the movement is simply rotary. During the locomotion of the creature, which proceeds in a spiral manner, Unger saw from one to three revolutions of the body in a second; and during rotation he noticed the point of the proboscis to be in a continual state of tremor. Unger endeavoured to show that the spermatic animalcules of the mosses are analogous to the spermatic animalcules of animal organisms, although we find certain features in the former not seen in the latter, and which may somewhat embarrass their classification, the chief of which are the steadiness of the spiral direction of the proboscis, and their manner of movement. Lately, Unger has found spermatic corpuscles in the antheridia of *Polytrichum juniperinum*, *P. commune*, *P. urnigerum*, and *P. alpestre*, as well as in *Funaria hygrometrica*, *Bryum cuspidatum*, *B. punctatum*, &c. In *Polytrichum commune*, the corpuscles are found in very small hexahedral cells with rounded corners. Generally, whilst in the cells they are motionless; in some, however, a tremulous motion of the thin proboscis was seen, and in others, again, a rotatory motion, interrupted at intervals. The diameter of the delicate proboscis is 0·004 of an inch. In a few corpuscles, isolated from their cells, a trembling oscillating motion of the proboscis was perceptible."

To these particulars may be added a remark of Dr. Unger, quoted in the *Ann. des Sciences Nat.*, which led to the introduction of the subject in this work.

"The doubts," Unger says, "which remain concerning some of the organs of the animalcules of mosses, further increase the uncertainty as to their situation in the scale of beings. From all circumstances, I am inclined to place them in the genus *Spirillum* of Ehrenberg, and to describe them under the name of *Spirillum Bryozoon*."

Mr. Varley, in his article on *Chara*, in the 50th vol. of *Trans. Soc. Arts*, has the following observations on the same structures:—

"From these cells" [in the globule of the axil of the *Chara*] "grow out numerous clusters of long vessels, possessing the most extraordinary features yet observed. When these are first protruded from the globule, if not quite mature enough, their appearance is like dense or strongly-marked ringed vessels, the divisions of which, or their contents, soon begin to appear irregular.... After a while, these curls within the divisions become agitated: some shake or vibrate; others revolve in their confined places; and many come out, thus showing that they are spirals of two or three curls; these, with an agitated motion, swim about.... Now the field of view appears filled with life: great numbers of these spirals are seen agitated and moving in all directions; they all have a directile force, one end going foremost, and never the other; many stray a great way out of the field: these, by getting clear of each other, are the best to observe; they do not quite keep their form as a stiff spiral, but their foremost end seems to lash about, and to many are seen attached almost invisible but very long fibres. These fibres were in quick undulations, which ran in waves from the spiral to their farthest end. It appears that these fibres cause many of the spirals to entangle together, and thus bring them sooner to a state of rest; therefore the separate ones were best to observe."

Among the more recent observations on these motile fibres (from the anthers of *Chara vulgaris* and *Ch. hispida*), are those of M. Thuret in the *Annales des Sciences Naturelles*, a translation of which will be found in the *Annals of Natural History*, vol. vii., from which we extract the following paragraphs:—

"The portion of their body most apparent appeared like a spirally-rolled thread, of three to five curves. They were slightly tinged with green, similar to the nuclei; and, like them, turned brown with iodine, their two extremities becoming more or less coloured (according to the quantity of iodine employed) than the rest of the body, thus indicating a difference of nature in these portions. At a little distance behind one extremity proceed two bristles, or tentacula, of excessive tenuity, which the animalcule incessantly agitates with great rapidity. These are probably organs of locomotion, similar to the filiform prolongation found in the Infusoria without cilia. Indeed, the part thus furnished with tentacula moves foremost, drawing after it the rest of the body, which turns about in the water, but always preserves its corkscrew form. The incessant agitation of these tentacula, and their extreme tenuity, rendered it impossible to observe them in the living animal; recourse was therefore had to the evaporation of the water, or to the application of a slight tincture of iodine, when the animalcules ceased their motions, became contracted, and their spiral unrolled, when the tentacula were rendered very distinct, from their brown colour. These tentacula were frequently observed to be soldered together from one-half to one-third of their length upwards; but others were also noticed to be entirely separated down to their bases. A swelling similar to that in the flexure of the body was perceived in their curves.

"Ammonia arrested their motions, and contracted the body gradually into a small oval mass, but did not produce the phenomenon of decomposition by solution (*diffluence*), so remarkable in the Infusoria. A very weak solution of hydrochloric acid in water violently contracted them into a shapeless mass."

In Plate XVII., figs. 520–522 represent the spermatozoa found in *Polytrichum commune*, the first figure exhibiting them enclosed in the cellules, and the others, swimming freely. Figures 522–524 are taken from *Marchantia polymorpha*. Figure 525 is from *Sphagnum capillifolium*. All the above are magnified 1000 diameters. Figures 526–528 are from the *Chara vulgaris*, and figures 529–531 from *Jungermannia pinguis*, as figured in Meyen's work (*Neues System der Pflanzen*).

On this subject of vegetable spermatozoa, Schleiden, in his recent work on the "Principles of Botany," remarks—"The doctrine of vegetable spermatozoa is now, I hope, gradually dying away. The granules (generally starch), taken from spermatozoa, have indeed lost their life in Fritzsche's tincture of iodine, since their evidently purely physical molecular movement remained undestroyed.

". . . . Fritzsche has completely settled the matter; and every unprejudiced observer may convince himself with ease of the completely untenable nature of the wonders formerly spun out, especially by Meyen. The confirmatory observations of Nägeli on this point are also of great value."

Again, he says—"As to the mechanism of the motion, we know just as little as we do of that of the moving cilia; of the cause of motion, of the motive power, just as much as of that of the contraction of the primitive muscular fibre, of the motion of animal spermatic filaments, and of the vibratile cilia on animal and vegetable cells; that is to say, absolutely nothing."

Further, in reference to the motion of the so-called spermatozoa, Schleiden observes—"There can be no question as to its not being a vital phenomenon, because the motions continue even in the alcoholic tincture of iodine (an absolute poison for all vegetable and animal life), of which one may readily convince himself, and which Fritzsche has, with his well-known accuracy, shown to be the case in a great number of plants." (Dr. Lankester's translation, pp. 99 and 359.) This assertion of Schleiden, that tincture of iodine is an absolute poison to all animal and vegetable life, must be received with reserve, since animalcular life has been known to exist in agents, such as strong acids and mineral poisons, which, *à priori*, would appear quite as inimical to it as tincture of iodine; and even minute animals—the *Acari*, of far higher organization than the Polygastrica, have been stated to preserve life in strong acetic acid.

Before dismissing this subject, it may be useful to append some observations made by Wagner and Leuckart, in their elaborate and original article before-quoted.

Having stated that, up to the most recent period, the so-named spermatozoa of animals have been considered independent animal organisms, or parasitical animals, and classed among the Infusoria, the authors proceed to say that such assumption is perfectly irreconcileable with our present knowledge of these bodies, derived principally from the discoveries of R. Wagner, Von Siebold, and Kölliker:—"With our existing means of scientific diagnosis it can be proved that the formations in question are mere elementary constituents of the animal organization, like the ova—constituents equally as necessary for the spermatic fluid as the blood-globules are for the blood. The remarkable phenomena of the life of spermatozoa are quite analogous to those phenomena of motion observable not only in animal formations, but also in vegetable structures—as, for instance, in the spores of Algæ and of the lower species of Fungi, and in the so-termed *Vibriones* which grow out into the fibres of the Conferva called *Hygrocrocis*. Moreover, an unprejudiced observation will prove that the spermatozoa are everywhere void of a special organization, and consist of an uniform homogeneous substance, which exhibits, when examined by the microscope, a yellow amber-like glitter. The opinion of an internal organization of the developed animal elements was not a little supported by the various remarkable phenomena of motion which were frequently perceived in them. In former times, when people had no idea of the existence and extent of the so-called automatic phenomena of motions which take place without the intervention or influence of the nervous system—when nothing was known of the motion very similar to a voluntary one which exists even in plants—this movement was certainly calculated to place the independent animal nature of the spermatozoa beyond a doubt. But it is different now. We know that motion is not an exclusive attribute of animals, and that an inference respecting the animal nature of the formations in question, however similar the motion observed in them may be to that of animal organizations, is a very unsafe and venturesome one.

"We know that certain elementary constituents, animal as well as vegetable, possess a power of movement, and that they retain it for some time after having been separated from the organisms to which they belonged. We only need here remind our readers of the so-called ciliated epithelium, the several cells of which swim about in the fluid surrounding them, and have not unfrequently, and that even quite recently, been considered independent animals; or, again, of the spores of the Algæ, which actively move by the aid of a ciliated investment, or of a single or manifold long whip-like fibre, until they eventually become fixed and develope themselves into a new plant. Such spores as these may be found described and illustrated in the well-known magnificent work of Ehrenberg, classified as Infusoria, under the groups of Monadina, Volvocina, &c.

"Under such circumstances we may consider ourselves perfectly justified in declaring every attempt to prove the parasitic nature of the spermatozoa by the characteristic of their peculiar motion, as futile and inadmissible."

Genus SPIRODISCUS (XVIII. 63).—Self-division imperfect and oblique, producing elongated chains, or inflexible spirals, of a disc-like figure. Its organization is so little known that Ehrenberg considers the genus as by no means satisfactorily determined; indeed there is little doubt that it is not a member of the Vibrionia.

SPIRODISCUS *fulvus*. — A lenticular spiral, of a yellowish brown colour. Articulation indistinct. XVIII. 63 represents three spirals, magnified 200 diameters. Amongst Confervæ. Breadth of spiral 1-1200".

Genus ZOOGLŒA (Cohn).—Cells (corpuscles) very minute, bacilliform, hyaline, aggregated together in a hyaline muco-gelatinous, globose grapelike, and subsequently membranaceous mass, from which they may detach themselves, and swim away with a vacillating movement.

ZOOGLŒA *Termo*. — Free, moveable cells, straight, from 1-2000''' to 1-700'''. It is equivalent to *Palmella infusionum* (E.), *Micraloa teres* (von Flotow), to some described forms of *Cryptococcus*, and to *Bacterium Termo* (Duj.), the *Vibrio Lineola* (E.) (XVIII. 69). (See Part I. p. 187 *et seq.*)

Genus METALLACTER (Perty).—*Bacterium*-like corpuscles, growing by repeated imperfect division into stiff or slightly flexible fibres (chains), which, under certain determinate conditions, eventually lose their power of movement and grow into *Hygrocrocis*-like, tangled, fibrous masses, colourless or of a greyish hue.

METALLACTER *Bacillus* = *Vibrio Bacillus*. — Articulation unobservable, or seen with much difficulty. *Vibrio subtilis* (E.) and *Bacterium Catenula* (Duj.) are, in Perty's judgment, nothing more than delicate and transparent varieties of this same organism. In Switzerland, in foul pond-water, at all seasons.

Genus SPORONEMA (Perty) (XVIII. 65).—Very minute, cylindrical, unarticulated, hollow fibres, closed at one end (rarely at both), frequently enclosing two elliptical corpuscles (probably spores).

SPORONEMA *gracile* (XVIII. 65). — Fibres from 1-700''' to 1-80''' long, and 1-1000''', and under, broad, of extremely pale-greenish tint. Often occurs with *Metallacter Bacillus*, which it much resembles; yet is always non-articulate. Movements tolerably quick, either end forward. Specimens occur where the spores distend the fibre; others contain none. In the sediment of pond-water containing Chara and Lemna, from various Swiss localities.

In Ehrenberg's system the family Closterina follows here, but in this edition it is transferred to the Desmidieæ, of which it constitutes an important genus. (See Part I. p. 1 *et seq.*)

FAMILY VI.—ASTASLÆA or EUGLENÆA (see p. 188).

(XVIII. 35–56; XX. 15–21).

The members of this family are, according to Ehrenberg, characterized by being deficient of a true alimentary canal and lorica, and by having a single aperture and the power of changing their form at pleasure. Their organs of locomotion consist of a tail in most cases, a single filament in three genera, and a double one in a fourth. It is probable that filaments exist also in the other two genera, *Colacium* and *Distigma*. The internal vesicles were presumed to be gastric sacs, although the usual test of their being so, viz. the application of coloured food, failed in Ehrenberg's hands; yet, he says, he noticed some manifestations of a digestive power in the green and red cells of *Euglena viridis*. In *Euglena* there are, besides green ova (granules), a gland (nucleus) and a contractile vesicle; but *Astasia*, *Distigma*, and *Colacium* exhibit only ova. Large red points are found in five genera. In *Euglena longicauda* and *E. amblyophis*, adds Ehrenberg, "the first indication of the presence of nervous matter to be found in the polygastric Infusoria" is met with in the form of a white glandular knot, situated below the eye.

The following table illustrates the characters of the genera of this family as instituted by Ehrenberg:—

Eye wanting					Astasia.
Eye present	With one eye	Free	With one proboscis	Tail wanting	Amblyophis.
				Tail present	Euglena.
			With two proboscides		Chlorogonium.
		Attached by a pedicle			Colacium.
	With two eyes				Distigma.

The family Euglenæa (Eugléniens) of Dujardin in a great measure corresponds with that of Astasiæa of Ehrenberg; but Dujardin prefers the term Euglenæa, on account of the resemblance of the other name to that of a family of Crustaceans, viz. the Astaciæa.

Dujardin looks upon the so-called eyes as insufficient to afford generic characters, which he would derive from the nature or apparent structure of the integument, and the number and mode of insertion of the filaments. On these principles he establishes a genus *Polyselmis*, characterized by its many filaments; two genera, *Zygoselmis* and *Heteronema*, by a pair of filaments, in the former of equal, in the latter of unequal size. The remaining Euglenæa, which have but a single filament, can be but uncertainly defined: such are the *Euglenæ*, mostly coloured, and having a red eye-speck and a tail; the *Astasiæ* without colour and tail, but with a filament flexible throughout, and springing abruptly from a notch in the anterior extremity; and the *Peranemæ* only differing from the *Astasiæ* in having a filament rigid at the base, and apparently a continuation of the tapering anterior extremity of the animalcule. The two last genera are, however, but provisional.

Astasiæa is one of the families in the group of Phytozoidia of Perty, who ignores the genera *Amblyophis* and *Distigma* of Ehrenberg, adopts the *Peranema* and *Zygoselmis* of Dujardin, and adds, as new genera, *Eutreptia* and

Dinema. Again, Schneider (*A. N. H.* 1854, xiv. p. 327) would separate *Chlorogonium* from the Astasiæa on account of its unchangeable form, and Mr. Carter (*A. N. H.* 1856, xviii. p. 116, and 1859, iii. p. 15) would refer *Euglenæ* to the vegetable, and *Astasiæ* to the animal kingdom. The differences prevailing among naturalists relative to the beings to be admitted into the family Astasiæa indicate either that its characters are not laid down with sufficient precision, or that it is not a natural group. The power to vary the figure can be no adequate character; for this is partaken by the gonidia of various Algæ in certain amœbiform stages of existence, and, on the other hand, is absent in some species enumerated by Ehrenberg in the genus *Euglena*, as well as in *Chlorogonium*. The tapering or tail-like prolongation of one extremity, the existence of one, two, or more ciliary filaments, as also of a red speck, are likewise features common to numerous zoospores. Even when appeal is made to their internal organization and functions, nothing appears whereon the definite characters of a natural family can be built. For, on the one hand, the organization assigned them by Ehrenberg is now held to be untenable, and, on the other, no harmony prevails respecting the internal structure as recorded by different observers of the various genera. Mr. Carter, in the paper just quoted, states unhesitatingly that most of the *Astasiæ* enumerated by Ehrenberg are animal forms, whilst the *Euglenæ* are vegetable. He remarks that, "although no two Infusoria can be more alike than *Astasia limpida* and *Euglena* when casually observed.... yet the absence of chlorophyll and the presence of a stomachal cavity, &c. for the digestion of crude food in the former, and the presence of chlorophyll and absence of a stomachal cavity, as well as of all means of taking in crude food for digestion, in the latter, are distinguishing characters which at once place *Astasia limpida* on the animal, and *Euglena* on the vegetable side, respectively, of the great organic kingdom; yet both Ehrenberg and Dujardin have classed *Astasia* and *Euglena* together."

If the organic difference between *Astasiæ* and *Euglenæ* be what Mr. Carter asserts, his proposition to divide the Astasiæa of Ehrenberg into two families, viz. Astasiæa and Euglenæa, must be accepted.

The Astasiæa inhabit ponds, mostly occurring on the surface, and frequently tinge the water with their own colour when their multiplication has been very rapid. When swimming, they present an elongated form, but when fixed, often appear as round globules. From their beautiful colour, their ever varying changes of form, and the rapidity of some of their vital acts, they are most interesting and pretty objects under the microscope, and from their common occurrence are almost always at hand for the student. Many are capable of progressing by alternately fixing and advancing the head and tail after the manner of a leech, as well as by the usual process of swimming.

Genus ASTASIA (XVIII. 36, 48, 49, 50).—Individuals free (not attached by a pedicle), and furnished with a long or short tail, but no eye-specks. *A. pusilla* is the only species in which vacuoles have been clearly seen. Ova (granules) are perceptible in *A. hæmatodes*, and probably exist in the three other species; a locomotive organ in the form of a thread-like proboscis exists in *A. pusilla*. Perty unites this genus with *Distigma*. The immense numbers in which these Infusoria are sometimes developed in a few days, and the blood-red colour they impart, have not unfrequently been the cause of considerable alarm and anxiety to persons residing in the vicinity of ponds or small lakes which have become blood-coloured by their swarming.

Dujardin's genus *Astasia* is defined as colourless, obtuse or rounded posteriorly; whilst those described by Ehrenberg are mostly green or red, and provided with a longer or shorter caudal prolongation.

ASTASIA *hæmatodes* (XVIII. 36, two figs.).—Body fusiform or spindle-shaped when extended; tail very short; body green at first, afterwards of a blood-red colour. The illustrations represent one creature extended, and another contracted. Hampstead. 1-380″. This species is referred by Dujardin and Carter to the genus *Euglena*.

A. *flavicans*. — Extensible, cone-shaped, approaching cylindrical, and rounded at the foremost extremity. Tail very short and blunt; granules of a yellowish colour. In yellow ditch-water. Length about 1-430″.

A. *pusilla*.—Extensible, cone-shaped, swelling out and rounded at the fore extremity, tail very short and pointed; colourless. Motor filaments above twice the length of the body. Movements slow; but rotation on the longitudinal axis rapid. Several phases of *Euglena viridis* resemble this species in form, molecular arrangement of contents, size, and motion, and are peculiar only on account of their green colour and red stigma. Ehrenberg remarks that they are often so abundant that thousands, perhaps millions, of these creatures are sometimes contained in the hollow of a watch-glass, and form a stratum on the surface of the water. They might be mistaken for the young of the *A. flavicans*, but that the vesicles within them are larger than those in that species, which is, moreover, without proboscis. As soon as a little colouring matter was thrown into the water, an evident current was observed near the fore part of the creature; and by this means, in 1833, the thread-like filament, which is about half the length of the body, was first perceived. Sometimes the entire creature appears to glisten. Should this species, upon closer inspection, be found to be ciliated, it would be rightly placed among Peridiniæa. 1-1440″ to 1-500″. The size of the vesicles remarked by Ehrenberg is no distinctive character; and Mr. Carter believes that both this species and *A. flavicans* are either identical with or very nearly allied to *A. limpida*, and therefore animal organisms, unlike the *Euglenæ*, to which they have a general resemblance.

A. (?) *viridis*. — Extensible; of an ovate-oblong form, distended a little at the middle; tail very short and pointed; green. Amongst Confervæ. 1-1200″ to 1-900″. This species and *A. hæmatodes* are, in Dujardin's opinion, members of the genus *Euglena*, the only appreciable difference between them being the presence of a red stigma in this genus. In this opinion Mr. Carter coincides.

A. *nivalis* (Vogt) (XVII. 532–533).—Oval, extremities rounded, rarely pear-shaped, colour deep reddish-brown, motion rapid. Found with *Protococcus nebulosus* in snow (Switzerland). 1-1500″. M. Vogt, in his account of the *Astasia nivalis*, describes it as invested with a carapace (lorica), open only at the anterior extremity. This opening is furnished with numerous small cilia; and here, doubtless, the mouth is situated, the indication of which is given by an orange-coloured tint, which is clearer than that of the rest of the animal. "The presence of a lorica and cilia affords a character which does not allow this animalcule to be placed with *Astasia*, as Shuttleworth has done; on the contrary, it ought to be placed in the family Peridiniæa (Ehr.), or else be regarded as the type of a new genus, distinguished by the absence of a groove in the lorica, and by the stiff hairs of *Peridinium* being replaced by soft cilia." (On the Animalcules of the Red Snow, *Bibl. Univ. de Genève*, 1841.) This presumed species is, in all probability, nothing more than an encysted corpuscle, probably a species of *Chlamydococcus*.

A. *Acus*.—Hyaline, figure long-fusiform, acute at each end; filament the length of the body. 1-650″. Berlin. Under the head *Astasia*, Perty enumerates the following species; but, as he makes no distinction between *Astasia* and *Distigma*, the generic appellation is not quite equivalent to that used by Ehrenberg.

A. *margaritifera* (Smarda).—Remarkable by its variability of form, or metabolia, the contents appearing to be driven from one part to another, filling and distending one portion, whilst the other is left empty and contracted. Hyaline granules (germs?) very distinct. At periods it loses its filaments, and with them its powers of swimming, when it adopts a crawling movement. Two clear spots occur near the base of the filament, which is once and a half to twice the length of the body: these spots were called eyes by Ehrenberg, who made them the distinctive feature of a genus *Distigma*. In pond-water, and even under ice, but not common. A variety, much elongated and slender, has been called *Astasia Serpentulus*.

The following species are described by Dujardin :—

A. *contorta* (XVIII. 49, 50).—Colourless, semi-transparent, containing pale-yellow granules; cylindroid, enlarged in the middle, obtuse at each end, and marked with oblique striæ, giving rise to a twisted appearance. 1-450″. In sea-water.

A. *inflata*. — Semi-transparent, diaphanous, contractile, ovoid, obliquely but regularly plaited or striated. 1-500″. In sea-water.

A. *limpida* (XVIII. 48 *a*, *b*, *c*). — Diaphanous, smooth, very variable, fusiform, more or less obtuse at each end, cleft anteriorly, and often obliquely doubled on itself or twisted. 1-650″ to 1-530″. In ditch-water. Perty remarks that Dujardin is wrong in identifying *Astasia pusilla* and *A. flavicans* with this species. Mr. Carter (*A. N. H.* 1859, iii. p. 15) treats this organism as an undoubtedly animal form, and describes it as having a stomach or digestive cavity, into which it receives food from without. Unlike *Euglena*, which it outwardly resembles, it contains no chlorophyll. He also considers that it is the same being which Ehrenberg has described and figured as *Trachelius trichophorus*.

A. *longifilis* (Perty).—Hyaline, with pale-green internal granules; filament at least three times longer than the body: a lateral plait or figure is seen in the anterior half. Form unchangeable. Motion tolerably fast. 1-1000″.

Genus AMBLYOPHIS (XVIII. 45).—Free, with a single eye-speck and flabellum, but no tail. The flabellum or filament serves as an organ of locomotion, and is situated at the fore extremity, which, says Ehrenberg, is cleft, so as to represent a two-lipped mouth, the filament being very readily distinguished on the upper lip. The colour of the animalcule is derived from the closely compressed mass of green granules, which nearly fills the body. Near the middle of the creature is a large, bright, globular, together with five wand-like bodies, two of which are situated before, and three behind the former; these structures together were supposed to be male generative organs. No contractile vesicle has been observed. Self-division is unknown. The coloured speck is very highly developed. Towards the anterior part of the body, and just behind the filament where the mass of granules commences, there is a bright-red and somewhat lengthened spot (resembling, as to situation and colour, the eye of the Rotatoria and Entomostraca), in the clear space beneath which is a mass of matter of a very peculiar description, of a globular form, having, to Ehrenberg's apprehension, the appearance of a nervous ganglion, and being most probably connected with the organ of vision. This genus is not distinct from *Euglena*; for the absence of the so-called tail is insufficient to distinguish it, and, what is more, Perty has seen *Amblyophis viridis* proceed from *Euglena viridis* in the process of reproduction.

AMBLYOPHIS *viridis* (XVIII. 45). — Large, elongated, cylindrical, distended or compressed, and abruptly rounded at the posterior extremity; green, head colourless; eye-speck large, bright red. The motion of this creature is sluggish and serpentine, and by its evolutions might easily be mistaken for the *Euglena Spirogyra*, were that creature, like this, tailless. Found with *Euglenæ*, chiefly in the spring. 1-210″ to 1-140″ (*vide* p. 194).

Genus EUGLENA (XVIII. 37-44, 46, 51, 52, 54).—This beautiful genus of the family Astasiæa is characterized by being furnished with an eye, a single thread-like filament, and a tail, and by being free. The locomotive filament is seen in nine species out of the eleven, and has a double appearance, in *E. sanguinea* ascribed to the condition of the animalcule preparatory to self-division. In *Euglena hyalina*, *E. pleuronectes*, and *E. longicauda*, vacuoles are generally visible; but in the other species they are obscured by the masses of green granules which colour their bodies. Certain internal appearances have been recognized, which Ehrenberg supposed to be of a male generative nature, *i. e.* a nucleus. Longitudinal self-division has been observed in *E. Acus*, and the commencement of it in *E. sanguinea* (XVIII. 37–39). Close to the red point a supposed nervous ganglion or eye-speck is visible in *E. longicauda* (XVIII. 44), such as is seen in *Amblyophis*. The genus *Euglena* of Ehrenberg, says Dujardin, contains some species of a compressed leaf-like form, and quite deficient of contractility, which require to be placed in the genus *Phacus* of the family Thecamonadina.

EUGLENA *sanguinea* (*Cercaria viridis*, M.) (XVIII. 37–39).—Extensible, of an oblong-cylindrical or spindle-shaped form, with head greatly rounded; tail short, conical, and somewhat pointed. Flabellum longer than the body in its extended condition. When young, they are green, but when full-grown, of a blood-red colour; and specimens are frequently found variegated red and green. The motion of this multiform animalcule is generally slow; and it sometimes revolves upon its longitudinal axis in swimming. The thread-like filament, which is a prolongation of the upper lip, and rather longer than the body, is so delicate as to require considerable care in investigating it, and, being retractile, will often elude observation. A little colouring matter in the water will exhibit this organ in active operation; and it may be distinctly seen in a single animalcule in a dried state, upon a plate of clear glass. The double appearance of the organ in this species has been before noticed. Ehrenberg conjectured that the miracle in Egypt, recorded by the great lawgiver of the Jews, of turning the water into blood, might have been effected by the agency of these creatures, or by the *Astasia hæmatodes*. In stagnant water, often in great abundance on the surface. 1-300″ to 1-210″. This is in all probability a mere variety of *E. viridis*; the red colour is not a specific distinction, but only a sign of maturity.

E. *hyalina*.—Extensible in a spindle-shaped manner; head attenuated, blunted at the extremity, and two-lipped; tail short, and somewhat pointed; colour transparent and whitish; rare. 1-280″. Perty asserts that it is only a variety of *E. viridis*.

E. *deses* (*Enchelys deses*, M.).—Extensible, cylindrical, abruptly rounded at the head, and slightly bi-lipped. Tail very short and pointed; colour green; motion a winding and sluggish creeping, never swimming. Filament very long and fine. Amongst Lemnæ. 1-240″ to 1-760″.

E. *viridis* (*Cercaria viridis*, M.) (XVIII. 46).—Extensible in a spindle-shaped manner; head attenuated and short. Tail short, and cone-shaped, not cleft; colour green, excepting the two extremities, which are colourless. The double-pointed tail represented by Leeuwenhoek and others does not exist. When the creature is young, its eye-speck is imperceptible or very pale, and it may readily be mistaken for *Astasia viridis* or *Monas deses*. When dried on glass, the speck seldom retains its colour more than a week; but the filament may be well examined and preserved when so treated. Filament twice the length of the body, which differs very much—between 1-600″ and 1-140″. Perty affirms that *E. hyalina* is a mere variety of this species, and that *Amblyophis viridis* (XVIII. 45) is the same, for he has witnessed the same individual *Euglena* produce both *Euglena* and *Amblyophis*. This observer has found *E. viridis* at an elevation of 9000 feet, on the Alps. On the surface of ponds at Hampstead and elsewhere, common.

E. *Spirogyra* (XVIII. 52).—Extensible and cylindrical; very finely striated and granulated. The head is a little truncated, and the hinder part attenuated into a short pointed tail; colour a brownish green; motion like *E. deses*. Its colour varies from a beautiful green to yellow or brown. It always occurs singly. *E. oxyuris* (Smarda) is not specifically distinct. Amongst Confervæ and Bacillaria. 1-240″ to 1-120″.

E. *Pyrum* (XVIII. 41, 42).—Obliquely fluted; when distended, oval or pear-shaped. The tail generally about the length of the body, and pointed; colour green. Found with many other species at Hampstead, but not so frequently as the other species. 1-1152″ to 1-864″.

E. *pleuronectes* (*Cercaria pleuronectes*, M.).—Compressed, ovate-orbicular, or in the form of an obovate leaf; striated longitudinally; colour green; tail pointed, one-third or one-fourth part the length of the body, and colourless. In stagnant water. 1-1152″ to 1-480″.

E. *longicauda* (XVIII. 44).—Mostly stiff, compressed, elliptical, and leaf-like; colour green; tail the length of the body, awl-shaped and colourless. Within this creature may often be seen a yellowish-green mass of granules. The very delicate vibrating thread-like filament has its origin from the more projecting side of an indentation on the anterior edge of the body, and is about two-thirds its length. This creature has the power of twisting its body into a spiral form, but not of contracting it. It swims freely, and mostly with a vibratory motion, occasioned by the action of the filament. In fresh-water amongst Confervæ and Bacillaria. 1-480″ to 1-120″.

E. *triquetra.* — Leaf-shaped, three-sided, oval-keeled; colour green; tail shorter than the body, and colourless. Amongst Lemnæ. 1-580″.

E. *Acus* (*Vibrio Acus*, M.).—Slender, spindle-shaped, and straight; head attenuated, and a little truncated; tail very pointed; body green in the middle, and colourless at the extremities. This is one of the most beautiful animalcules seen under the microscope; its graceful form when swimming, its bright-red eye, the curious forms it assumes when stationary, and its remarkable appearance when undergoing self-division, all combine to render it worthy of observation. Fresh and brackish water. 1-570″ to 1-110″.

E. *rostrata.*—Elongated and conical, with the hinder part gradually attenuated into a very short tail. Head slightly bent, like a beak; colour green. Amongst Oscillatoriæ and Bacillaria. Length about 1-500″.

E. *Ovum.*—Ovate, green, with a very short hyaline caudal prolongation, and a large, double, circular nucleus. 1-1560″. Berlin.

E. *geniculata* (D.).—Green, elongated, cylindrical, flexible but not very contractile; movement slow; tail tapering, clear, and at an angle with the body—hence the name. 1-208″ to 170″. This large *Euglena* is remarkable by its elongated form, by its diameter being nearly equal to its length, without the bulging of *E. viridis*, and by its articulated tail.

E. *obscura* (D.). —Thick, oblong; distended and obtuse posteriorly; but the form very variable; clearer and of a red tint anteriorly, eye-speck reddish-black; filament half as long again as the body. 1-870″. This form Perty surmises to be only a deeper-coloured specimen of *E. sanguinea*, which he often found of a brown or blackish-red colour.

E. *mucronata* (Perty).—Of a beautiful green colour, the anterior segment or head frequently hyaline, with a clear-red stigma; tail pointed and transparent. Body oval, often longitudinally and finely striped. Filament overlooked. Differs from *E. geniculata* by the absence of the angularly-set filament. 1-108″ to 1-84″.

Mr. Carter describes the following new species from the freshwater tanks of Bombay:—

E. *fusiformis.*—Short, thick, fusiform, obtuse, of a rich green colour, provided with a long, delicate, single cilium, which projects from a slightly bilabiate anterior extremity; a little behind which is the eye-spot, attached to the contracting vesicle. Nucleus central, situated between the ends of two elongated, refractive, nucleated cells, which extend round the body equatorially. Tailless. Motion during progression oscillatory, and rotating on the longitudinal axis. Length about 1-700″, breadth about 1-1100″. Freshwater tanks in the island of Bombay.

E. *zonalis.*—Short, thick, ovoid cylindrical, slightly narrowed anteriorly, of a rich green colour; provided with a long delicate cilium, which projects from the notch of a slightly bilabiate anterior extremity; a little behind which is the eye-spot, attached to the contracting vesicle. Nucleus central, between the ends of two wide, refractive, nucleated cells, which extend round the body equatorially. Tail adhesive or suctorial (?), short, about one-sixth part of the length of the body. Motion during progression oscillatory and rotating, on the long axis of the body. Length 1-1100″, breadth 1-1800″. Freshwater tanks in the island of Bombay.

These two *Euglenæ* are remarkable for having that refractive cell or organ which I have called the "glair-cell" equatorial, instead of longitudinal as in *Euglena Spirogyra*, or single and in the anterior lip as in *Crumenula texta.*

E. *agilis.*—Is a third species Mr. Carter would distinguish; but he has given no details, except relative to its development in the still form. 1-600″. In the brackish waters of the marshes of Bombay (*A. N. H.* 1856, xviii. p. 246).

Genus CHLOROGONIUM (p. 195) (XVIII. 47; XX. 15–21).—*Astasiæ* with a double filament. Are free and provided with an eye-speck, tail, and double filament. The only known species is of a very beautiful green colour, and has numerous transparent vesicles within it. A distinct, hyaline nucleus is perceptible in the centre of the animalcule. Self-division of the contents into four or more segments has been observed to take place, also propagation by microgonidia. Schneider and Perty concur respecting the propriety of detaching *Chlorogonium* from the Astasiæa. Numerous dull-red specks are scattered throughout its green contents, no one of which has the clearness and distinctness of the stigma of *Euglenæ*. The primordial envelope, with its enclosed green contents, varies in figure; but not the external one, which is rigid.

CHLOROGONIUM *euchlorum* (XVIII. 47; XX. 15–21).—Spindle-shaped, very pointed at both extremities; tail short; colour sparkling green. The eye-speck is so delicate that it may be easily overlooked; but when the creature is dried upon a plate of very clear glass, both the eye and the double filament are readily seen, and it may be preserved as a permanent microscopic object. XVIII. fig. 47 represents a cluster of six, each with its double proboscis. In water-butts, on ponds, &c.; it forms the green matter of Priestley. 1-110″ to 1-280″, exclusive of the tail. It was in this species that M. Weisse thought he had discovered a form of propagation analogous to that by ova, but in fact to reproduction by microgonidia (XX. 15–21). The young forms so produced, especially in their aggregate state before discharge, resemble *Uvella Bodo*; and M. Weisse thinks *Chlorogonium euchlorum* and *Glenomorum tingens* only other stages of development of the same organism.

Genus COLACIUM.—Eye-speck or stigma single. Filament not detected in this genus, although, as Ehrenberg remarks, there can be no doubt of its existence, from the currents which are visible in coloured water near the forepart of the body; still, as these are rather feeble, it is probable that the organ is but single. Numerous transparent vesicles are seen within the body. The creatures are parasitical upon Entomostraca and Rotatoria, to which they attach themselves by means of a pedicle or footstalk, which is single at first, but becomes ramified by the process of self-division.

COLACIUM (?) *vesiculosum*.—Spindle-shaped, oval, but variable; pedicle very short, and seldom ramified; colour sparkling green, with distinct internal vesicles. Ehrenberg says, "I have again sought in vain for the red eye (May 23, 1835), but cannot be satisfied of its non-existence, as it is undoubtedly present in the other species, and investigation is sometimes unproductive on account of subordinate circumstances. I have likewise failed in seeing very satisfactorily the vibratory organ, notwithstanding its action is evident enough." Found upon Entomostraca. 1-860″.

C. *stentorinum*. — Form variable, but somewhat cylindrical, prolonged anteriorly into a funnel-shaped process; colour beautiful green; vesicles indistinct; pedicle often ramified. The eye-speck is at one time distinct, at another scarcely perceptible; it differs also in position so widely that sometimes it is close to the elongated neck, at others near the posterior end. Perty surmises it to be a larval condition of some other being, or merely a sporozoid. Found upon Entomostraca and *Polyarthra trigla*. 1-1150″.

Genus DISTIGMA.—*Astasiæ* with two eye-specks. Locomotive organs not hitherto discovered; and the presumption is that they do not exist; none of the species either swim or produce perceptible currents in coloured water. Movements creeping or crawling, much like those of eels; form variable, like that of *Lacrymaria*; and they approximate to *Amœba* in other respects, besides the absence of a flabellum. At the fore part of the body may be seen two very delicate, blackish-coloured spots, analogous to the eye-specks in other genera. The *Distigmæ* are sometimes confounded with *Proteus* *diffluens* of Müller. All the species are exquisite objects for a deep-powered microscope—for instance, one magnifying 460 diameters. Perty unites this genus with *Astasia*, as being indistinguishable from it by any sufficient characteristics.

DISTIGMA *tenax* (*Proteus*, M.).—Larger than either of the other species; proteus-like—at one time greatly distended, at another as much constricted; eye-speck rather indistinct; colour transparent yellow. About Lemnæ. 1-240''. This species Perty regards as merely a larger variety of *Astasia margaritifera*, incapable of the same extent of metabolia.

D. *Proteus* (*Proteus*, M.).—Smaller than the preceding; proteus-like—sometimes greatly distended, at others constricted; blunted at both extremities; eye-specks distinct. Amongst Confervæ. 1-580'' to 1-400''. This species, says Perty, appears nothing else than a smaller specimen of *Astasia margaritifera* which has lost, to a greater or less extent, its filaments, and therewith its power of swimming, whilst it retains the remarkable peristaltic movements in its internal substance.

D. *viridis*.—Smaller than either of the other species; proteus-like sometimes greatly distended, at others constricted; filled with green granules; eye-specks distinct. Length not exceeding 1-570''. *D. viridis* is, in Perty's opinion, an incomplete condition of *Eutreptia viridis*.

D. *planaria*.—Small, linear; proteus-like, but capable of less distension or constriction than the preceding; pointed at both extremities; colourless; eye-specks distinct. Found by Ehrenberg amongst Confervæ in the Nile. 1-240''.

Genus PERANEMA (Duj.) (XXVI. 13).—Body of variable form, sometimes almost globular, at others distended posteriorly, and drawn out in front, or prolonged into a long tapering filament. Movement forwards slow and uniform. The *Peranemæ* are colourless, but contain in their diaphanous substance granules and vacuoles. The lobes they send out in their frequent and remarkable changes of form are, unlike those of the *Amœbæ*, covered with an integument. Found in stagnant marsh-water, chiefly on the surface of dead plants. I suspect Ehrenberg has described a species (*P. protracta*) of this genus under the name of *Trachelius trichophorus*.

PERANEMA *protracta*.—Oblong, soft, dilated posteriorly, much extended anteriorly. 1-838'' to 1-370''. Its figure undergoes changes by the movements of its contents. A trace of a red stigma often discoverable.

P. *globulosa* (XXVI. 13).—White or pale-green, nearly globular, more or less extended anteriorly, with oblique plaits on its surface. In the Seine, and in ponds at Bern. 1-1625'' to 1-1300''. Perty could not discover the plaits or folds, and states that the filament is double the length of the body. Movements very active.

P. *virescens*.—The animalcule so named occurred in the water of the Seine, was green, semi-fluid, and changed form most rapidly, like an *Amœba*. 1-800'' to 1-520''. Requires further examination.

Genus ZYGOSELMIS (Duj.) (XXVI. 12 *a*, *b*).—Animal of variable form, swimming by means of two equal flagelliform filaments, which are constantly in agitation. *Zygoselmis*, says Dujardin, is distinguished from *Diselmis* by its contractility and its variability of form; but such a distinction is surely insufficient.

ZYGOSELMIS *nebulosa* (XXVI. 12 *a*, *b*).—Colourless, sometimes globular, at others top- or pear-shaped, with numerous contained granules. 1-1300'', with two filaments of equal size and length. Uncommon; found with Lemna; the changes of form proceed slowly.

Z. *inæqualis* (Perty).—Colourless, hyaline; one filament rather stouter than the other; both protruded in front. Cavity sometimes filled with clear green corpuscles, which frequently assume optically a red hue. Changes of figure slow; movements sluggish. Distinguished from *Z. nebulosa* by the inequality of its filaments. 1-840''. The assigned distinction between this and the other species appears to us insufficient.

Genus HETERONEMA (Duj.) (XXVI. 11).—Body of variable form, oblong, irregularly dilated posteriorly, having a fine flagelliform filament, and a second thicker trailing one acting as a retractor. This genus, by possessing the two filaments of different characters and office, approaches the *Heteromita* and *Anisonema*, from which, however, it is distinguished by its contractile, obliquely striated integument.

HETERONEMA *marina* (XXVI. 11).—Body oblong, irregularly dilated behind, narrower in front, obliquely and closely striated. Length 1-434". In sea-water.

Genus POLYSELMIS (Duj.) (XXVI. 7).—Animal oblong, of variable form, swimming by means of several flagelliform filaments which arise from its anterior extremity. The single Infusorium I have found possessing these characters resembled an oblong *Euglena* rounded at each end, with an anterior longer moveable filament, surrounded by three or four very fine shorter ones.

POLYSELMIS *viridis* (XXVI. 7).—Elongated, rounded at each end; more or less dilated and folded in the middle; green, with a red eye-speck. 1-650". Found in a glass of marsh-water containing Lemna, which had been kept several months.

Genus EUTREPTIA (Perty) (XVIII. 53–55).—Like *Chlorogonium*, *Zygoselmis*, and *Dinema*, has two filaments. It has besides the form of an *Astasia*, but its figure is constantly varying as it swims, and it has a red stigma.

This and the following genus constructed by Perty are very imperfectly characterized, and in our opinion have slight claim to generic independence.

EUTREPTIA *viridis* (XVIII. 53–55; XIX. 18–19).—Green, with hyaline corpuscles, but sometimes quite colourless. A variety thick and rounded posterior, with the outline of *Amblyophis*, only presented a crawling movement, and not the power of swimming. Length, when extended, 1-240". Among Lemnæ. A variety, *E. unifilis*, has only a single flabellum and a faintly marked stigma.

Genus DINEMA (Perty) (XIX. 17).—Filaments two; one projected in advance, the other trailed behind. Body small, saccular, very contractile, and destitute of chlorophyll.

DINEMA *griseolum* (XIX. 17).—Body filled with grey molecules. Movements sluggish, and particularly so the rotation on its long axis. Filaments about equal in dimensions. 1-250". Bern. In ponds, &c.

D. *pusillum*.—Colourless, with few internal granules. Very contractile, and changeable in figure.

FAMILY DINOBRYINA.

(XXII. 42, 48, 49.)

THE animalcules of this family are distinctly, or to all appearance, polygastric, and furnished with only one aperture to the body; hence, like polypes, they can have no true alimentary canal. They are possessed of an external case or sheath, and have the power at will of changing their form, but are without appendages, except one species of *Dinobryon*, which has a simple filiform proboscis and a delicate red spot at the anterior portion of the body. The nutritive apparatus is obscure and undefined. The lorica is of the form of a little pitcher (urceolus), to the bottom of which the very contractile Euglena-like creature is attached. Two genera only are known.

Genus EPIPYXIS (XXII. 42).—The characteristics of this genus are mostly of the negative kind; it wants the eye, and is attached. The most evident animal character possessed by the species is the funnel-shaped orifice at its anterior extremity. The soft or pulpy body is lodged within a delicate membranous (not silicious) lorica, usually affixed by a pedicle or foot.

Stein presumes *Epipyxis* to be merely a younger condition of *Dinobryon*, with which it occurs frequently in company. Besides this, the peculiar cell-like nucleus occurs alike in *Epipyxis* and in *Din. Sertularia*.

EPIPYXIS *Utriculus* (XXII. 42).—Small, conical, and pitcher-like, filled with yellowish granules; attached by a pedicle. The figure represents a group of several attached to a portion of Conferva. 1-640″.

Genus DINOBRYON (XXII. 48–49).—Distinguished from the preceding genus by possessing an eye-speck and freedom of motion. The lorica also is larger and looser around the body of the creature. Reproduction takes place by gemmæ, which do not separate from the parent; hence a shrubby, forked, and polype-like cluster is produced.

DINOBRYON *Sertularia* (XXII. 48, 49).—Lorica (sheath) large, slightly excised and dilated at the mouth, but constricted above the base or the attached extremity. This animalcule is readily overlooked, by reason of its crystalline lorica, and often nearly colourless body; by a patient investigation, however, the little colony may be perceived rolling along, and advancing in the field of view. Within each lorica a pale-yellow animalcule may be noticed, in form somewhat resembling the young of *Chlorogonium* or of *Euglena viridis*. The creature is able to contract itself into a rounded mass at the bottom of its case, or it extends itself to the mouth of the lorica, but not beyond it. A red speck occurs at the anterior part of the body, from which a single thread-like filament is protruded beyond the sheath. The vibrating filaments of the several members of the colony propel it through the water like so many paddles. In bog-water. Length of animalcule 1-570″, cluster 1-120″. Stein in the course of his researches met with a specimen of *Dinobryon Sertularia* which he likens to a Eugleniform being, living in a crystalline goblet-like sheath, much like that of *Vaginicola crystallina* or of *Cothurnia imberbis*. The sheaths grouped on a stem are only mechanically united together, and are under no circumstances developed by progressive gemmation from the hindmost one, as Ehrenberg supposed. Each being has a clear, homogeneous, discoid nucleus near its base, containing a central nucleolus.

D. (?) *sociale*.—Small, enveloped in a shell of a simply conical shape, truncated at the mouth. Developed in the form of a shrub-like polypary. In fresh water. 1-860″, cluster 1-280″.

D. *gracile*.—Less branching (fruticose), lorica slightly constricted at the middle, aperture truncated. Animalcule 1-2080″.

OF THE GROUP PROTOZOA (p. 199).

IN the arrangement pursued in the first part of this work the Protozoa follow the Phytozoa, and are primarily divided into two chief subsections, viz.—Rhizopoda and Ciliata. These we shall treat as two groups of Infusoria, divisible into a few subgroups, and, commencing with the Rhizopoda, shall treat systematically, first those beings properly called so, and afterwards, as subgroups, the Actinophryina and the Acinetina. The Ciliata and their divisions will follow next.

GROUP II.—RHIZOPODA (p. 201).

(Plates XXI.–XXIII.)

THIS term and its synonym Pseudopoda are derived from the leading characteristic of the class, viz. the variable processes or false feet which serve as their locomotive organs. The former appellation is more in vogue, but its extent of signification is ill-defined. Some would apply it to the whole collection of animalcules composed, as far as their organic material is concerned, of the self-same simple homogeneous sarcode, whether this exist naked, as in the Amœbæa, or whether enclosed within a simple single-chambered shell, as in the Monothalamia, or in a many-chambered or compound one, as in the Polythalamia or Foraminifera. Siebold extends to the Rhizopoda, as a class, this wide signification. Others, and among them Ehrenberg, would so far limit it as to assign to it only the naked Amœbæa and the monolocular Arcellina. Indeed, the last-named author holds the opinion of an actual difference in organic nature between his presumed Polygastric Pseudopoda and the Foraminifera or Polysomatia. Dujardin adopted the peculiar course of rejecting the Amœbæa from the Rhizopoda, which in his system included both monolocular and multilocular forms. In our general history of the Rhizopoda (p. 201), we have used the term in its widest signification, to include naked monolocular and multilocular beings; but, in order to keep this systematic portion of our work within moderate bounds, we shall here give only the descriptive account of the Amœbæa and Arcellina. Were another reason required than that assigned for this proceeding, a strong one might be found in the fact of the approaching completion of an elaborate work on the Foraminifera by Professors Williamson and Carpenter, who are so well known for their extensive acquaintance with this class of organisms.

Families:—1. Amœbæa; 2. Monothalamia (Arcellina); 3. Polythalamia (Foraminifera); 4. Actinophryina; 5. Acinetina.

FAMILY I.—AMŒBÆA OR AMŒBINA.

The Amœbæa present the simplest form of organic life, and are typically represented by a microscopic particle of 'sarcode,' or muco-gelatinous organic matter, possessing within itself the power of growth, of assimilation of extraneous substances, of movement by means of irregular and ever-changing offshoots from itself—"variable processes,"—and capable of multiplication by the severance of portions of itself, and probably of development by internal germs or gemmules. They present no definite, constant figure, although it is possible to distinguish different Amœbæa by the more frequent outline they exhibit, or by the length or figure of their pseudopodes. The general opinion is that the sarcode of which they consist is naked and homogeneous; but Auerbach (see *antè*, p. 205) has advanced the statement that they are all enclosed within an integument. A movement of granules is perceptible, especially along the margins of the variable processes. A nucleus with a nucleolus is believed to be generally present; vacuoles are almost always distinguishable; and one, two, or even more contractile vesicles have been seen in some specimens. There seems evidence of the process of encysting taking place under certain conditions. Amœbiform beings are not necessarily of an animal nature; for some have latterly been proved to occur in the cycle of development of some of the simplest plants. Ehrenberg described Amœbæa as polygastric animalcules, having a mouth but no alimentary canal, and moving by variable processes, produced from any part of the body indifferently. He observed vacuoles (digestive sacs) in all, and self-division in *Amœba diffluens*. The Amœbæa are organically related to the Arcellina and Foraminifera, from both of which groups they differ by being naked, or unenclosed in a shell (see p. 234).

Only one genus is distinguishable, viz.

Genus AMŒBA, which is therefore represented by the description of the family. The following species, however, are distinguished, although it is hard to define specific form in such variable creatures.

AMŒBA *Princeps* (XXI. 4).—Colour pale yellow, processes numerous, of a cylindrical outline, with thick, rounded extremities. Its figure when in a passive or non-reptant condition is globular; but this character is of no specific value, the natural tendency of any similar semi-fluid, mucous particle being, by the force of cohesion, to assume such a form. Amongst *Naviculæ* and Algæ in fresh water. 1-140″ to 1-70″.

A. *verrucosa*.—Smaller than the last; colourless; processes globular, ovoid, of a wart-like appearance. Motion sluggish, like, indeed, all *Amœbæ*. Never exceeds 1-240″. Amongst aquatic plants.

A. *diffluens*.—Colourless; expands into a filmy form and throws out processes which are longer than those of *A. verrucosa*, and rather pointed at the ends. This species is a very interesting object under the microscope: at times it resembles a turbid lump of jelly-looking matter, at others a transparent gelatinous film, with numerous outstretched processes slowly protruded at one part and withdrawn into the general mass at another, but so acted on as to serve to produce a very slow onward movement. Its movements may be compared in appearance to those which may be imagined as exhibited by a many-footed animal tied up in a sack. Usual size 1-300″. Common amongst Lemnæ.

A. *radiosa* (XXII. 1-3).—Colourless; smaller than *A. diffluens*; processes numerous, long, slender, pointed, disposed in a radiating manner. When contracted, it resembles *A. diffluens* in its globose figure. Colouring matter is readily taken into its substance. In bog-water. 1-240″.

A. *longipes*.—Very small; processes very long, one of them often four times the length of the body; acute and hyaline, without expansions. 1-2500″. Cuxhaven, in the sea.

A. *Rœselii* (Duj.).—Diaphanous; processes numerous, some very obtuse, others digitate, and others also pointed or jagged. 1-130″. Large vacuoles occur about the middle of the body, looking like large globules.

A. *marina* (D.).—Filled with granules at the centre; differs from *A. diffluens* only in its dimensions and habitat, *i. e.* the sea. 1-260″.

A. *Gleichenii* (D.).—Varies from a globular to a very long-oval figure; dividing into two or three lobes on one side; vacuoles, and some nearly opaque granular bodies, at the centre. 1-400″ to 1-300″.

A. *multiloba* (D.).—This may be but a variety of *A. Gleichenii*, but deserves pointing out, as much from the circumstance of its habitat as from its form. 1-1300″. It seems softer than other species, and moves actively, emitting from its border in various directions ten or twelve rounded lobes, which give it a most irregular figure. It was found in an infusion of meal which had been kept nearly two months.

A. *Limax* (D.) (XXII. 4-5).—Diaphanous, rounded on each side, more or less globose, and but slightly lobed; glides along in a nearly straight line; contains very distinct granules, and a very clearly marked vacuole. Found in Seine water kept for eight months. It may be but a more advanced degree of development of the preceding, or of the following species; its greater transparency, however, and its semi-fluid consistence, seem sufficiently distinctive. 1-260″ to 1-800″. Auerbach suggests that this species is only a young form of *A. Princeps*.

A. *Guttula* (XXII. 6).—Diaphanous, orbicular or ovoid; glides in a straight course, and contains very distinct granules. This is one of the most common species, but may easily escape notice on account of its great transparency, the simplicity of its form, and the slowness of its movements. In river- or marsh-water, kept for some time, containing plants. 1-520″ to 1-890″.

A. *lacerata* (D.).—Symmetrical, rugose, plaited, and granular, rather diaphanous, with broad expansions, looking membranous at the base, terminated by several tapering torn points; one or more evident vacuoles. 1-2800″ to 1-890″. In pond-water.

A. *brachiata* (D.).—Globular; semi-transparent, porous and tubercular, with four to six very thin long and cylindrical expansions, straight or flexuose, sometimes bifid or branching. In animal infusions. 1-190″.

A. *crassa* (D.).—More or less rounded, thick; contains numerous granules; expansions rounded, numerous, not very prominent. 1-880″ to 1-520″. In the water of the Mediterranean.

A. *ramosa* (D.).—Globular or ovoid; granules very numerous; expansions numerous, of nearly equal size, rounded at the extremities, of the same length as the body, and mostly branched.

Other varieties of these peculiar beings are referred to, but not specially described, by Dujardin; for one, however, he proposes the name of *Amœba inflata*.

A. *quadrilineata* (Carter). — 1-350″. Mr. Carter has given this name to a supposed new species (*A. N. H.*, 1856, xviii. pp. 243, 248), of which he gives a diagram, but no specific description.

A. *lateritia* (Fresenius).—Rounded or oval, or drawn out at one end and rounded at the other. Processes thin, finely pointed; points very numerous; colour of a brick-red, becoming browner after death. In water at Walldorf with *Spirotænia*. 1-20 to 1-10 millim.

A. *actinophora* (Auerbach) (XXII. 12–18).—When without processes, its form is more or less globular; and even when pseudopodes are protruded, the figure is usually not much altered, those processes being thin and spicular with pointed ends (fig. 13), though they do not exceed in length more than 1½ the diameter of the body. This species is remarkable for the number of crystalline particles found in its interior, and for the processes never being entered by the granules of the interior of the body. Auerbach believes that the *Actinophrys viridis* of Ehrenberg is probably no other than a large specimen of this *Amœba*. It is closely allied to *A. bilimbosa*, but is smaller, its surface smooth, its processes radiating and simple, not forked, its envelope thinner: it contains the peculiar crystals, and has no starch-globules as seen in the latter. 1-110‴ to 1-70‴. In water at Breslau.

A. *bilimbosa* (Auerbach) (XXII. 7–11, 20–23).—Figure more or less globular when processes absent or few; pseudopodes vary, being either wide and laminar with a spinous or dentate terminal margin, or elongated and tubular. 1-50‴ to 1-35‴.

A. *porrecta* (Schultze) (XXI. 3).—Hyaline; processes numerous from all sides of the irregularly-shaped mass, from eight to ten times longer than the latter, divergent like so many fibres, with intercommunicating branches. Fissure very changeable and rapidly so; remarkably locomotive. The fine granules seen to circulate through the processes. In fresh and salt water.

A. *globularis* (Schultze) (XXI. 2).—Granular, delicate, yellowish-brown, central portion surrounded by a hyaline cortical lamina, from which the short, stumpy processes are very slowly protruded and withdrawn. Most of the processes are also remarkable from their rounded truncate ends being terminated by a retractile spine. Ancona.

A. *polypodia* (Schultze). — Processes numerous, long, slender, with rounded or truncate extremities, and hyaline; movements tolerably active. Lagoon-water, Venice.

A. *Schultzii* (XXI. 1).—A species indicated but not named by Schultze; to distinguish it, we have applied to it that eminent naturalist's name. Central portion granular; surrounding lamina hyaline; no granules enter the interior. Processes short, tubercular, with rounded extremities. Possibly the same as *A. verrucosa* (Ehr.). In long-kept water from Ancona.

Supplementary Genera, or Subfamily of AMŒBINA.

Genus CORYCIA (Duj.).—An Amœbiform being, covered by a very expansible, elastic, flexible membrane or sac, which becomes folded in different directions by the movements and contractions or expansions of the animalcule, —the whole organism sometimes, after it has several times turned on itself, looking like a folded piece of linen. The membrane remains distinct after the animalcule is torn by needles, and the sarcode particles evacuated. The latter contract themselves into little balls, and, by the property of vacuolation, become hollowed by little cavities in larger or smaller numbers. The contents consist, besides sarcode, of granules, vacuoles, and foreign particles; the first-named move in currents from one part to another. The expansions are not pushed forward, nor do they glide along the surface of reptation like those of Arcellina or of naked *Amœbæ*; they proceed from various points of the general mass or body, and seem to serve rather to change the centre of gravity than to furnish a *point d'appui*. 8-100‴ to 20-100‴.

The name is suggested by the membranous envelope, which preserves the animalcules from being dried up during the alternations of dryness with moisture they are exposed to by their habitat in mosses. They are procured by lightly pressing the Jungermanniæ, moistened by the rains of November or December, or after they have been preserved a little time in water.

This, as Dujardin remarks, is evidently a new genus, intermediate between the naked and the loricated Rhizopoda, and standing in a certain relation with the *Noctilucæ*. (*A. S. N.*, 1852, vol. xviii. p. 240.)

No species named.

Genus PAMPHAGUS (Bailey).—An Amœbiform being, covered by a delicate elastic integument, which, although it presents astonishing changes of form, and offers a certain amount of resistance to internal and external pressure, yet admits of the animalcule transfixing itself upon any denser thin portion of matter without any apparent damage (p. 220).

They connect, says their discoverer, "the genus *Amœba* with *Difflugia*, agreeing with the first in the soft body without shell, but differing in having true feelers or rhizopods confined to the anterior part of the body," or to the region of the mouth, as in *Difflugia*. A specimen of *Pamphagus*, we may remark, is equivalent to a *Difflugia* without a true shell and with no extraneous matters to thicken and strengthen its covering. Dr. Bailey met with these animalcules in a vivarium, into which "bits of boiled beans and potatoes had occasionally been introduced as food for other animalcules," and numerous starch granules were found in their interior. He also represents it as having a mouth, and, being an adherent of Ehrenberg, as polygastric; but the mouth so described was the orifice of the sac through which the pseudopodes were protruded, and therefore the homologue of the foramen of monothalamous shells.

This genus is evidently very closely allied to *Corycia* (Duj.). The only difference of moment is that in the latter the expansions of the sac proceed from any part of the surface, whilst in *Pamphagus* its discoverer describes them as given off only from one spot at the anterior end.

FAMILY II.—ARCELLINA (Ehr.) (Pt. I. p. 201 *et seq.*) (XXI. 6–17.)

Amœbæ invested with a single-chambered cell or lorica, having also but one opening, mouth, or foramen. The animal substance or sarcode contained within the shell is indistinguishable from that of the naked *Amœbæ*, and is not more organized. The form of the pseudopodes given off from around the mouth of the shell are to some extent employed in defining species; but the size and conformation of the shell and of its opening are of much more importance systematically.

Ehrenberg instituted this family for all one-chambered Rhizopodous shells which, in his belief, were of a silicious composition, and rejected from it some similar shells which were of a calcareous character. This distinction, however, is based on erroneous notions (p. 219); and naturalists now concur in bringing together all unilocular Rhizopoda into one group, under the name of Monothalamia.

The Arcellina were represented by Ehrenberg as polygastric animals, with an alimentary canal, and enclosed by a lorica, through the single opening of which they extended their variable processes. He also described digestive sacs, but was unable to discover either their mode of reproduction or their multiplication by fission or gemmæ.

Only four genera of Arcellina were enumerated by Ehrenberg; their characters and mutual relations are shown in the following tabular view :—

Changeable processes radiant, generally numerous	Lorica spherical or tun-like....	Difflugia.
	Lorica a flat spiral	Spirillina.
	Lorica discoid or shield-shaped	Arcella.
Changeable processes broad and unbranched		Cyphidium.

The genus *Spirillina* is a very exceptional form; it has a spirally-coiled shell, apparently porous throughout, like one of the Foraminifera, and like them, too, a marine habitat. Its only affinity with the Arcellina, according to Ehrenberg's account, is the silicious nature of the shell; but even were this established, it would not exclude it from the Foraminifera, among which silicious testæ are known. Of *Cyphidium* little information exists; and Ehrenberg's account is by no means satisfactory. The same may be said of the figures he gives of it.

Dujardin divides the "Rhizopodes," excluding the Amœbæa, into two sections, according to the form of the variable expansions. The first section corresponds to the family Arcellina of Ehrenberg, and comprehends those species provided with short thick expansions, rounded at the extremity. Such are the *Difflugiæ*, possessing a flexible membranous lorica, without visible texture, mostly of globular form, from the aperture of which the expansions radiate: such, too, are the *Arcellæ*, having a discoid lorica, flattened on the side-along which they move (the plane of reptation), where is a central round opening, from which the expansions proceed, the latter lying thus between the shell and the surface along which it glides; the lorica, moreover, is brittle, and often reticulated, or areolated. The second section, much larger, comprises beings of every variety of form, and having very numerous filiform expansions, ending by very fine extremities. Of these varieties he makes three tribes; the first distinguished from the *Difflugiæ* only by the slender character of the expansions, except that in one genus, *Trinema*, the opening is lateral; the second, represented by the genus *Euglypha*, having a lorica beset with tubercles, or areolæ, disposed spirally; and the third by the genus *Gromia*, having a spherical membranous shell, and very long and branching expansions.

The remainder of the "Rhizopodes," as described by Dujardin, are comprehended in the Polythalamia by other authors. Of these he constitutes two tribes,—one represented by the single genus *Miliola*, which, like *Gromia* and the examples of the first tribe, has but a single large opening in its lorica for the escape of the expansions; the other by several genera, all of which give off numerous filiform expansions from many distinct pores (foramina) of their shells, and hence called *Foraminifera*.

Siebold included the first and second divisions of Dujardin's class *Rhizopoda* in his group of *Arcellina*.

M. Schultze framed the division of the Monathalamia from the structure of the shells; but he admitted amongst them the genus *Orbulina*, which possesses the very exceptional character of having numerous pores to its shell, instead of a single opening. The three families instituted were:—1. Lagynida; 2. Orbulinida; 3. Cornuspirida (see p. 241). The first-named family corresponds most nearly to Ehrenberg's Arcellina, although it contains several genera usually described in histories of the Foraminifera, and omitted by the Berlin naturalist. The following are enumerated:—*Arcella*, *Difflugia*, *Cyphidium*, *Trinema*, *Euglypha*, *Gromia*, *Lagynis*, *Ovulina* (d'Orbigny), *Fissurina* (Reuss), *Squamulina*, and the doubtful genera of Schlumberger—*Lecquereusia*, *Cyphoderia*, *Pseudodifflugia*, and *Sphenoderia*. The genera *Lagynis* and *Squamulina* are two new ones formed by Schultze himself. It will make this history more complete to introduce these new genera of Lagynida, as well as the interesting *Cornuspira* described by Schultze. Of *Fissurina* we have no details.

Dr. Bailey, of New York, adds another new genus to the Monothalamia, under the name of *Cadium*.

Genus DIFFLUGIA.—Shell of one chamber (unilocular) with a single aperture, usually of a more or less spherical or ovoid shape, but sometimes more elongated and clavate, or pitcher-shaped; thin, opaque, of a dark olive or brown colour, in general, when occupied by the living organism, but when empty, hyaline and colourless. The surface of the shell is either smooth or sculptured, and occasionally armed with spine-like processes. In a few species, *D. proteiformis*, *D. acuminata*, and *D. gigantea*, the envelope does not acquire even the usual horny consistence, but is soft, and becomes strengthened by the adhesion of foreign particles of silex and other matters, which give it a rough, irregular appearance. The aperture or foramen varies in figure and size, and furnishes valuable specific distinctions. The pseudopodes are characterized as being cylindrical, not much elongated, and obtuse or rounded at the extremities.

DIFFLUGIA *proteiformis*.—Ovate, subglobose, covered by a coating of minute grains of sand, and either of a deep olive, black, or greenish colour. Processes hyaline, from 1 to 10. 1-240″. Among Oscillatoriæ.

D. *oblonga*.—Oblong, ovate, or orbicular, smooth, and of a brownish colour; processes fewer and stouter than those of the preceding species. Among Oscillatoriæ, &c. 1-200″. Surface irregularly reticulated.

D. *acuminata*. — Oblong and rough, with minute grains of sand; posteriorly pointed; processes hyaline. 1-70″.

D. *Enchelys* (XXI. 19 *a*, *f*).—Oval; colourless; translucent and smooth, rounded dorsally; processes transparent, slender and small; aperture lateral. This is the smallest species of the genus. 1-30‴ 1-15‴. In stagnant water. Dujardin refers it to his genus *Trinema*.

D. *Ampulla*.—Oblong, club-shaped, elegantly marked by an oblique series of dots (puncta); hyaline; foramen ovate. 1-680″. At Salzburg.

D. *spiralis* (Bailey).—Sub-globose, minutely granulated: upper surface unequal, with a spiral line of two or three turns. Variable processes numerous, constantly changing position, hyaline. 1-680″. Berlin and United States. Fresenius remarks that some large specimens are met with coated with coarse particles, like D. *proteiformis*, instead of the usual finely reticulate lines. It attains, he says, in size to 1-7‴.

D. *acanthophora* (XII. 64). — Ovate, oblong, loosely areolated; foramen dentated; armed posteriorly with three or four spines (aculei).

D. *areolata*.—Lorica and foramen as in the preceding, but the spines deficient.

D. *denticulata*.—Ovate, oblong, smooth; foramen with twelve dentations.

D. *Lagena*.—Clavate, or of the form of a bottle; smooth, without reticulations; margin of opening entire.

D. *lævigata*.—Ovate, oblong, smooth; foramen with eight dentations; approaches *D. denticulata*.

D. *striolata*.—Ovate, oblong, delicately striated longitudinally; foramen with a dentated border.

D. *Brueteri*.—Ovate, surface rugose; the end presenting the aperture rather attenuate but truncate; margin of aperture entire. 1-1050″. On moss.

D. *cancellata*.—Oblong, obtuse; surface beset with imperfectly rounded cells, 5 to 6 in 1-2500″; aperture narrow, entire. 1-1040″. On moss.

D. *ciliata*. — Ovate, surface areolar; each posterior areola furnished with a cilium or cirrhus; constricted towards the foramen, which has 10 to 16 denticulations. 1-936″. Common in Hercynia.

D. *seminulum*.—Shorter, ovate, brown, surface with narrow and small areolæ; aperture wide, very finely denticulated or entire. 1-2500″ to 1-1250″. On moss and stones.

D. *collaris*.—Narrowed like a neck behind the aperture; straight, attenuate, pyriform or sub-clavate; surface irregularly cellular; cells small, but of equal size, except about the neck, where they are smaller; aperture entire. 1-840″. About roots of trees.

D. *Dryas.* — Ovate; aperture entire, truncate; surface marked with longitudinal lines of ovate cells, which decrease in size posteriorly. 1-1170″. On roots of trees.

D. *oligodon.* — Smooth, oblong, subcylindrical; aperture with eight strong denticulations. 1-1000″. This spacies and the two following found in Kurdistan.

D. *reticulata.*—Ovate, surface marked by a net-work of minute cells; aperture simple, large. In its interior are numerous particles like aggregated buds; the margin of the foramen is sometimes dentate. 1-880″.

D. *squamata.*—Ovate, with large loose areolæ, looking like scales (squamæ); aperture denticulate, truncate, contracted. 1-1450″.

D. *spirigera.*—Pyriform, smooth; neck distinct, cylindrical, truncate; orifice large, entire; opposite end turgid; rounded. The surface presents four spiral longitudinal lines. 1-36‴. Bavarian Alps.

The first of the appended species is from Dujardin, the others from Schlumberger (*Ann. des Sciences Nat.* 1845, p. 254):—

D. *globulosa* (XXI. 10).—Brown, globular, or ovoid, smooth. 1-260″ to 1-105″. Near Paris.

D. *depressa.*—Diaphanous, ovoid, depressed, resistant; its surface divided by slight fissures (lines) into numerous small and irregular polygonal sections. 1-220″. Aperture with an uneven margin. In springs in the Vosges.

D. *gigantea.*—Greyish brown, rough, as if strewed with particles of sand, ovoid, elongated, and contracted anteriorly. 1-325″ to 3-325″. It approaches *D. proteiformis,* but differs in its more elongated form, in being contracted anteriorly and almost pyriform, sometimes depressed, and lastly in its greater size: margin of aperture uneven.

D. *tricuspis* (Carter).—Processes occupied by granules, greenish; testa ovoid, little incrusted; its foramen tricuspid in form, or of trefoil shape (*A. N. H.* 1856, xviii. p. 247). Fresenius appears to have met with this form, but considers it only a variety of *D. oblonga.* 1-320″.

D.? *marina* (Bailey).—Shell silicious (?), ovoid or lagenoid, with a contracted neck and circular aperture; surface divided by oblique lines into quadrilateral spaces. $\frac{1}{24}$ of 1-1000″, diam. $1\frac{1}{4}$ of 1-1000″.

A single specimen was found in soundings taken from a depth of 2750 fathoms, which had been cleaned with acids. This resistance to acids induced Dr. Bailey to consider the shell silicious, but we now know that chitinous shells are equally unaffected. The discoverer doubted its being a *Difflugia,* on account of its marine habitat.

Genus SPIRILLINA.—Lorica tubular, silicious (?), rolled in a spiral manner, like a *Planorbis.* It is allied to *Difflugia* by its silicious lorica (for acids have no action on the shell). This genus probably agrees with the *Spirulina* of Bory de St. Vincent; but the latter name has been otherwise used by Ehrenberg to designate a genus of Polythalamia.

Spirillina *vivipara* (XI. 37).—Shell porous, convoluted as a circular, spiral, horizontal tube, hyaline and smooth. Young loricæ may often be found connected with it. In the sea—Vera Cruz, Mexico.

The form of this species recalls that of many undoubted Polythalamia, whilst it has no fellow amongst the Infusoria. Ehrenberg has likewise represented apparent dots or pores on its surface, like those through which the filiform processes of Polythalamia are protruded; and the only reason implied in Ehrenberg's account for reckoning it among the Polygastrica is its silicious shell: it is, however, most probably chitinous. It will be noted that Ehrenberg is inclined to believe it viviparous.

Genus ARCELLA (XXI. 7–9, 15).—Variable processes, numerous and hyaline; single processes cleft into many, and expanded in a radiating manner; lorica flattened, shield-like. The lorica varies much in structure in the different species. For instance, in *A. vulgaris* it exhibits regular and delicate facets; in *A. dentata* the facets are large and crystalline; in *A. aculeata* it is beset with spicula; and in *A. hyalina* it is homogeneous and clear. Vacuoles are seen filled with coloured vegetable substances; and in

A. vulgaris and other species a contractile vesicle has been perceived. The processes are longer, as a rule, than those of *Difflugia*, fibrous, and more branched. The shells are very commonly compressed, and have a discoid figure; and in none are they soft and beset with extraneous particles, as in *Difflugia*, but are chitinous and elastic.

"The *Arcellæ* (says Dujardin) seem to differ among themselves by the intimate structure of their lorica, which sometimes appears membranous, at others finely striated, reticular, or with granules disposed in spiral lines. Some *Arcellæ* have also spinous prolongations from the border of their lorica. Pressure fractures their lorica like a brittle substance. The contained substance escapes through the cracks so formed, in the form of contractile expansions like those of *Amœbæ*. I have seen one larger lobe almost separated, as if about to become an independent being. M. Peltier has observed contact to take place between the expansions of neighbouring *Arcellæ* without any union being effected, while the processes of the same *Arcellæ* united and became blended together.

"The lorica in young *Arcellæ* is extremely diaphanous; and granulations or striæ are to be seen only in those of larger size: hence it may happen, with respect to some species, that they represent but different stages of existence of the same animal."

ARCELLA *vulgaris* (XXI. 7, 8, 9).—Lorica round and bell-shaped, with a hemispherical or turgid back; smooth, but with rows of minute granules; colour yellow or reddish-brown. Abundant amongst Lemnæ and aquatic plants. 1-570" to 1-240."

A. *aculeata*.—Yellowish, hemisperical, though often mis-shapen, and spinous throughout, or only around one-half of the margin; the shell is not readily destroyed by heat, and is covered with short spicula. 1-210".

A. *dentata*. — Membranous; of a hemispherical or polygonal form; margin dentated; colour yellow or green. Amongst Confervæ. 1-570" to 1-240".

A. (?) *hyalina*.—Membranous, smooth, elliptical or globular, smaller than the preceding, thin and soft, colourless. Found in débris at the bottom of pond-water, along with *Cyphidium aureolum*, &c. 1-1150 to 1-570". The shell is not quite symmetrical, one side being more convex than the other. Aperture sometimes irregular. Ehrenberg was not certain that this species is not a *Difflugia*. It is indeed very like many specimens of *D. Enchelys*.

A. *Americana*. — Oblong; aperture small, round, not in the median line.

A. *constricta*.—Ovate; slightly contracted about the foramen, which is very large and to one side.

A. *disphæra*. — Oblong, almost divided into two by a central constriction; one-half nearly occupied by the large foramen. This is a very doubtful *Arcella*, and contrary in form to the character of monothalamous cells. A comparison of Ehrenberg's account with his figures leads us to believe this supposed species to be no other than a young *Rotalia* of two cells (XX. 41), or other incomplete polythalamous shell.

A. *ecornis*.—Large; hemispherical, not areolar; aperture round, large, placed to one side; entire.

A. *lunata*.—Subglobose, large; with a wide semi-lunar opening, seated to one side.

A. *Nidus-pendulus*. — Ovate-oblong, hyaline, loosely areolated; aperture in front, oblong, margin entire.

A. *Pileus*.—Hemispherical, depressed, reddish, minutely and elegantly areolar; aperture central, circular.

A. ? *Globulus*. — Subglobose; with loosely reticular lines, appearing granular; aperture large, simple. 1-730". On moss at Berlin, Potsdam, &c.

A. *granulata*.—Oblong, hyaline. Has the habitat and size of *A. hyalina*, with a granular instead of a smooth surface. 1-940". On moss in Hercynia, &c.

A. *caudicola*.—Ovate, oblong, rounded at each end, hyaline, very delicately hispid, not areolar; aperture anterior, round, large. 1-840". Habitat of *A. Nidus-pendulus*. In Venezuela, on roots of plants, such as ferns, &c.

A. *Okenii* (Perty) (XXI. 15).

Genus CYPHIDIUM (XXII. 24–27).—Has only one dilated variable process, and a lorica of the form of a pitcher, with protuberances issuing from it. The lorica is combustible, and is something like a little die or stamp, mounted upon a short stem. It is very irregularly formed, having protuberances which make it appear four-cornered. The organ of locomotion is a broad gelatinous variable process with smooth edges, not unlike *Amœba verrucosa*. Vacuoles have not yet been observed; modes of propagation unknown.

CYPHIDIUM *aureolum* (XXII. 24–27).—Lorica cubical, with protuberances; process colourless. "In March, 1835," says Ehrenberg, "I first observed hundreds of these creatures in a glass of water which had stood throughout the winter, in company with some specimens of the *Micrasterias*. Previously to discovering these, the *Amœba verrucosa* had been abundantly generated, and afterwards *Arcella hyalina*. The creatures were inactive, although by attentive observation they might be seen to change their places." Ehrenberg only once perceived the locomotive organ of the animalcule, situated under one corner,—upon which it appeared to rest, and that so firmly that six out of the eight protuberances of the die-like lorica were visible at the same time. In fig. 26 the gelatinous variable process is seen projecting from beneath the lorica. Fig. 27 is a young specimen. 1-570″ to 1-430″.

Genus TRINEMA (Duj.).—Shell membranous but resistant, diaphanous, ovoid elongated, narrower in front, with a large oblique orifice placed laterally; expansions filiform, as long as the shell, very thin, and but two or three in number; entirely retracted when others are to be pushed out from another side. The animal is moved onward by their alternate protrusion and contraction. This genus is accepted by Fresenius.

TRINEMA *Acinus*. = *Difflugia Enchelys* (Ehr.) (p. 553).

Genus EUGLYPHA (Duj.).—Shell diaphanous, resistant, membranous, elongated, ovoid, rounded at one end, terminated at the other by a very large truncated orifice, with a dentated margin; its surface marked by eminences or depressions, in regular oblique series; expansions filiform, numerous, simple.

EUGLYPHA *tuberculata*.—Lorica striated, with rounded tubercles. Termination of expansions extremely delicate. 1-295″. Found in stagnant ponds.

E. *alveolata* (XXI. 11).—Lorica with regular polygonal depressions in regular oblique (spiral) series, bearing spines at the upper or posterior end. 1-290″.

Genus GROMIA (XXI. 12, 16) (Duj.).—Lorica smooth, yellowish-brown, membranous, soft, globular, with a small round opening, from which the very long branching expansions proceed, tapering to very fine extremities. Found in both salt and fresh water.

GROMIA *oviformis*.—Globular, smooth, aperture sorrounded by a short neck; expansions very long, fibrous, branching, slightly anastomotic, colourless or pale-yellow, transparent; animal contents of a yellow or reddish-brown colour; the processes hyaline, permeated by a current of granules. Shell 1-26″ to 1-13″.

G. *fluviatilis*. — Globular, or ovoid, without a neck; expansions palmate and anastomotic. 1-290″ to 1-104″.

G. *hyalina* (Schlumberger, *A. S. N.*, 1845, p. 254).—Globular or rather ovoid, smooth, soft, diaphanous, colourless; foramen round, with a very short neck, formed by a reflexion of the lorica; expansions filiform, numerous, very fine, branching and anastomotic. 1-865″ to 1-520″. In rivulets.

"Notwithstanding the absence of colour in the shell," says Schlumberger, "I arrange this species in the genus *Gromia*. In size it also differs from the other two species. The lorica, being transparent, admits to view some bluish globules, and a large hyaline glandular ovoid body, like that in the interior of other diaphanous Rhizopodes."

G. *Dujardinii* (Schultze).—Shell spherical, ovoid; more constant in figure than *G. oviformis*, colourless or faint yellow, with a short neck-like elongation at the foramen, or none; animal contents dark sepia-brown; processes hyaline, with no moving granules. Diam. 1-2‴. Ancona.

Genus LECQUEREUSIA (Schlumberger).—Shell ovo-globular, or retort-shaped, rather depressed, membranous, but resistant; with a wide short neck, and circular terminal aperture, giving passage to cylindrical thick and obtuse expansions.

This genus approaches *Difflugia* (Duj.) in the character of its expansions; but the very different form of the shell, and the position of the aperture, sufficiently mark the distinction between the two. Its distinctness is regarded with doubt by Schultze.

LECQUEREUSIA *jurassica*.—Shell resistant, diaphanous, grey, of a globular figure, but rather depressed, with a short wide neck. Length about 1-250"; breadth 1-315".

This beautiful species is met with on aquatic plants, in many of the lakes of the Jura chain about Neuchatel. Its diaphanous lorica allows its interior soft hyaline and granular body, strewn with brown specks, to be seen.

Genus CYPHODERIA (Schlum.). — Lorica membranous, resistant, ovoid, elongated anteriorly, where it is curved and constricted in the form of a neck; surface marked by prominent points in oblique rows; aperture circular, oblique; expansions very long, filiform, very fine at the extremity, and simple or branching.

The oblique disposition of the rows of points, the obliquity of the aperture, and the character of the expansions, bring this genus into affinity with *Trinema* (Duj.); but the constriction, forming a neck, seems sufficiently distinctive between the two. This genus, though admitted by Fresenius, is treated as doubtful by Schultze.

CYPHODERIA *margaritacea*. — Lorica yellow; the surface is divided into minute facets, which appear like translucent points or rows of pearls. Processes attain twice the length of the shell, and are simple or branched. Length 1-395"; breadth 1-840" to 1-408". Common in the water of the Vosges with vegetable débris. The form of the lorica varies; at one time the neck may be but rudimentary; at another the posterior end, instead of being wide and rounded, is contracted suddenly to a truncated apex. Aperture crenulate.

Genus PSEUDO-DIFFLUGIA (Schlum.). — Shell membranous, ovoid or ovo-globular, smooth or striped spirally, with a wide round opening, whence proceed numerous long slender expansions, either simple or branching.

This genus is allied to *Difflugia* by the form and character of its shell, but differs from it in the nature of the expansions; it is admitted as doubtful by Schultze.

PSEUDO-DIFFLUGIA *gracilis*. — Shell bluish brown, brittle; surface as if beset with minute grains of sand, of a more or less elongated ovoid figure; expansions filiform, very long. Length 1-740" to 1-465"; breadth 1-890" to 1-740". Found near Mulhouse.

Genus SPHENODERIA (Schlum.).—Shell diaphanous, colourless, resistant, globular, with a flattened wedge-shaped neck; surface marked by polygonal depressions, disposed in regular oblique rows; aperture terminal, compressed, almost linear. Expansions filiform, very long and attenuated.

The form of the aperture and of the neck separates this genus from *Trinema* and *Euglypha*, to which it is allied by the structure of its lorica. Schultze treats it as a doubtful genus.

SPHENODERIA *lenta*.—Lorica as above described, expansions few, very long, slender and simple, or branching. 1-650" to 1-520".

Of all the Rhizopodes I have examined (says Schlumberger), this is the slowest in its movements, and its expansions the most difficult to discover. I have found it on tufts of moss in marshy rivulets.

A glandular body and hyaline globules are seen in the internal soft substance near the posterior end. In moving, the position of the shell may be perpendicular, or oblique to the surface of reptation: the hexagonal depressions are indistinct but large. The shell fractures along the lines of junction between the hexagons.

Along with the preceding genera, Schultze, as before stated, includes in the division Monothalamia the new genera *Lagynis*, *Squamulina*, and *Cornuspira*.

Genus LAGYNIS (Schultze).—Shell membranous, elastic, retort-shaped; body colourless, transparent; foramen large, but the processes few, very fine, occasionally branching.

It forms the type of the family Lagynida.

LAGYNIS *baltica*.—The transparent contents rarely fill the shell, but leave a space posteriorly, into which they send processes which converge towards the summit of the concavity of the posterior, rounded extremity. 0·05‴. Baltic Sea.

The form of the shell approaches that of *Euglypha* (?) *curvata*, described by Perty, and found in an empty state by him on the Simplon, at an altitude of 4000 to 5000 feet.

Genus SQUAMULINA (Schultze).—Shell calcareous, plano-convex, or lenticular; adherent by the plane surface; cavity single, one large opening on the convex side; no pores.

SQUAMULINA *lævis*.—Irregularly circular; much flattened; convex portion thick and smooth, the flat portion very thin and scarcely separable from the object to which it adheres. The yellowish animal protrudes numerous processes from the excentric foramen. Largest diam. 1-26‴. Sea-water, Ancona.

Genus CORNUSPIRA (Schultze).—Shell calcareous, spiral, like a Planorbis shell; solid or finely porous; discoid; symmetrical, *i. e.* with both sides alike; cavity single. One large foramen at the termination of the spiral.

CORNUSPIRA *planorbis*.—Shell translucent, brown, without pores; six or perhaps more turns of spiral seen. Mud from the coast of Mozambique and Trieste.

C. perforata.—Finely porous, hyaline, colourless; pores circular, becoming gradually larger towards the termination of the spiral; as many as seven turns seen. On the coast of Mozambique.

D'Orbigny's *Operculina inserta* is probably the same form. The *Spirillina* described by Ehrenberg is somewhat like, but is probably only a young *Miliola*.

Genus CADIUM (Bailey) (XXII. 19).—Shell silicious (chitinous?) ovoid; elongated as a sort of neck, which is bent upwards and outwards, terminated by a circular foramen.

This genus was instituted by the late Dr. Bailey, of New York, to include some empty Rhizopodous shells met with in the soundings taken in the gulf-stream. (*Silliman's Journ.* xxii. 1856.)

CADIUM *marinum* (XXII. 19).—Shell marked by numerous meridian lines, of which about 12 are visible at once. Length 2-1000″; diam. 1¼-1000″.

Sub-group ACTINOPHRYINA. (Part I. p. 243.)
(XXIII. 24-37.)

A sub-class of Rhizopoda having a more constant and definite form, and furnished with long tapering retractile filaments or tentacles, which serve as prehensile organs, in the place of the usual variable processes of the class.

Their movements are excessively slow, and sometimes inappreciable; and the tentacles appear not concerned in them: conjugation is of very frequent occurrence.

The genera enumerated in this section are *Actinophrys*, *Podophrya*, *Trichodiscus*, and *Dendrosoma*. The distinction between the two first-named genera is denied by Stein, and probably with reason, for the stem of *Podophrya* is not sufficiently characteristic (*vide* Part I. p. 243). *Trichodiscus* is little known to observers, and probably is only a variety of *Actinophrys*; and *Dendrosoma* has hitherto received little attention; its branched pedicle, however, gives it a generic importance.

Dujardin formed a very correct conception both of the organization and affinities of the Actinophryina, which were coupled with Amœbæa and Rhizopoda in his second order of Infusoria. He rejected the genera *Podophrya* and *Trichodiscus*, which he merged in the genus *Actinophrys*. Siebold very strangely overlooked the true structure and affinities of *Actinophrys*, which he placed with Enchelia, in company with the very dissimilar *Prorodon*, among his "Stomatoda."

Perty has constituted *Actinophryina* a second section of Ciliata, and has adopted the genera *Actinophrys*, *Podophrya*, and *Acineta*. *Trichodiscus* he regards as only a compressed form of *Actinophrys*, and treats *Dendrosoma* as an aggregated one, in which the individual beings are collected into colonies.

Genus ACTINOPHRYS (XXIII. 28–32).—Body more or less spherical, usually compressed or discoid, sometimes irregular in outline, owing to the projection of superficial vacuoles. Tentacles tapering, terminated occasionally by a rounded head (*i.e.* capitate), pretty uniformly distributed, their length generally exceeding the diameter of the body; retractile, and for a time lost in the substance of the body, but reappearing at the same place and under the same form. The tentacles serve for prehensile instruments, but not for locomotion. Food is introduced within the body at any part, and not through a mouth; and its excrementitious portion is in a similar manner discharged from any part of the exterior. Internally are one or two contractile vesicles, placed immediately beneath the surface, a nucleus with a nucleolus, alimentary vacuoles, granules, and probably small nuclear cells. Reproduction takes place by fission, and in *Dendrosoma* by gemmation. Germinal development is presumed, and conjugation is a frequent phenomenon.

The proboscis mentioned by Ehrenberg appears to be a sort of expansion of the sarcode of the body, homologous with a variable process, which envelopes and then drags the prey into the general mass.

Ehrenberg believed he had discovered a mouth, anus, and polygastric structure, and that he had succeeded in demonstrating this last by feeding with coloured food. He likewise adopted Eichhorn's statement—that the tentacles acted as locomotive organs, by giving the animalcules the power to crawl.

The specific distinctions hitherto attempted are really of little worth; even the highest authorities are in doubt, and disagree among themselves, respecting the specific names of the animalcules they so elaborately describe; and the revision of the several forms and varieties of *Actinophrys* is urgently required before any satisfactory separation into species can be made. We append those forms which have been accounted specific by different authors.

ACTINOPHRYS *Sol* (XXIII. 28, 31, 32).—Colour whitish, or rather grey; figure spherical, or nearly so; the tentacles or rays diverge from every part of the surface, and taper to their extremities, and equal the diameter of the body in length. Found in the dust-like matter upon the surface of infusions, and among Confervæ and various aquatic plants. Stein asserts that these habitats are those of A. *Eichhornii*; not of *A. Sol*, which does not occur as a free being. 1-110‴ to 1-53.‴

This species has been very much confounded with *A. Eichhornii.* Kölliker mistook this last for *A. Sol*; and Claparède wrote his description of *A. Eichhornii*, and afterwards discovered it was *A. Sol* that he had investigated. Indeed the brief characters furnished by Ehrenberg are quite inadequate to identify the species.

A. *Eichhornii* (XXIII. 29). — Large, white, globose; tentacles shorter than the diameter of the body, and tapering. The cortical and medullary layers are well distinguished; the former contains numerous vesicles. Tentacles contractile, seen to bend themselves in the prehension of food, &c. Stein affirms that the being which Ehrenberg described and figured under this name is no other than *A. Sol*, that the tentacles are by no means always shorter than the diameter of the body, but often longer, and that this circumstance of relative length cannot be used in the diagnosis of the species, but that the conical figure of the tentacles is distinctive. Stein's views on these specific details must be received *cum grano salis*; for the influence of his Acinetiform hypothesis pervades his systematic history of the beings of the class under notice, and his figures of *A. Sol* prove him to have been in error either in the observation or in the interpretation of the organism; for they indicate a member of the Acinetina rather than of the Actinophryina. Perty seems to think the largest specimens of *A. Sol* constitute *A. Eichhornii* (Ehr.).

A. *oculata* (Stein) (XXIII. 24, 25).—Round, more or less discoid, with several concentric circles of vesicular spaces distributed over the surface of the animalcule, giving it an undulated outline. The tapering, pointed tentacles arise from the eminences of the surface, and are equal in length to the diameter of the body, except in small specimens, in which they rather exceed it. The periphery of the body is covered with a homogeneous, transparent, gelatinous, apparently thick layer, within which the large, vesicular, non-contractile spaces, filled with water, are found. Besides this superficial layer, a cortical and a medullary substance are clearly pronounced. The particles of food do not enter the medullary substance. The finely granular nucleus is central, surrounded by a ring of clear medullary matter. Pressure, after the action of acetic acid, will sometimes detach it as a free body, invested by a membrane, and having within it an ill-defined granular nucleolus. Diam. 1-38‴ to 1-35‴.

A. *viridis* (Ehr.).—Spherical, greenish; rays numerous, shorter than the diameter of the body. Diam. of body 1-620″ to 1-280″. Amongst Confervæ.

A. *difformis*.—Irregularly lobed, depressed, and hyaline; rays variable in length, some exceeding the diameter of the body, which is from 1-570″ to 1-280″. The animalcule thus described Stein apprehends to be nothing more than several young specimens of *A. Eichhornii* conjoined (conjugated).

A. *marina* (Duj.).—Differs from *A. Sol* in its habitat, and in the more marked contractility of its rays. Amongst microscopic Algæ in the Mediterranean. Probably a mere variety of *A. Sol.*

The claim of *A. viridis*, *A. difformis*, and *A. marina* to specific distinction is extremely doubtful. The green colour of the first is immaterial, and the relative length of its rays to the body of no specific importance. The irregularly-lobed outline of *A. difformis*, again, is an immaterial condition; for the soft bodies of true Actinophryina admit a changeable outline, and the reception of food, moreover, to a certain extent involves it. Dujardin justly attributes no other value to his species *A. marina*, than that it may serve to indicate an *Actinophrys* living in the sea.

A. pedicellata (Duj.) = *Podophrya fixa.*

A. *digitata*.—(Duj.).—Depressed; rays flexible, thicker at the base, forming, when contracted, short, thick, finger-like processes. Diam. 1-750″. In fresh water containing marsh-plants. Its discoid body would rather place it with *Trichodiscus.*

A. *granata* (Duj.) (*Trichoda granata*, M.).—Globular, opaque at its centre, surrounded by rays of less length than its own diameter.

A. Discus (Duj.) = *Trichodiscus Sol* (Ehr.).

A. *ovata* (Lachmann). — A species named by this naturalist in *A. N. H.* 1857, xix. p. 221.

A. *brevicirrhis* (Perty).—Of a dusky yellowish green colour, rarely colourless; tentacles much shorter than the diameter of the body; not capitate, but bristle-like. Its outline is double, with a green or red line. Length 1-600'' to 1-500''. Bern. Among Confervæ.

A. *Stella* (Perty) = *Trichodiscus Sol.*—It is to be regretted that Perty, whilst recognizing this organism to be an *Actinophrys*, should not have adopted Dujardin's very appropriate name for it, rather than encumber the student with another.

Genus TRICHODISCUS.—Body depressed, with a single marginal row of setaceous tentacles; vibratile cilia and teeth absent; no pedicle; mouth truncated (Ehr.).

These Infusoria, by their flat disciform shape, resemble *Arcellæ*, but, unlike the latter, are soft and illoricated, with stiff, bristle-like rays. A central opening, and a large lateral gland (nucleus), have been recorded by Ehrenberg, who likewise states that he has seen, though indistinctly, numerous digestive cells, but neither the reception of coloured food, nor an anal orifice.

This account is very unsatisfactory as a means of determining a genus. The discoid figure is not a sufficient distinction from the genus *Actinophrys*; and, on the other hand, the softness of the integument, compared with the lorica of *Arcella*, is not a generic distinction; for the so-called lorica of the latter genus is in many instances only a flexible integument.

Cohn (*Zeitschr.* 1853, Band. iv. p. 262), after remarking on certain Actinophryean beings covered with adherent foreign particles of sand, *Cyclotella*-shells, &c., and surmising that such beings were no other than *Difflugiæ* engaged in the formation of a lorica, submits the opinion, in a foot-note, that *Trichodiscus Sol* (Ehr.) is a similar organism, because Ehrenberg describes its tentacles as proceeding from the middle of the body, which is often partially coloured with brownish corpuscles.

TRICHODISCUS *Sol.* (*Actinophrys Discus*, D.).—Depressed, almost flat, hyaline or yellowish, with variable rays. The motion of this species is very sluggish; it often remains for a long time inert. Amongst Confervæ. Diam., without rays, 1-430'' to 1-210''.

Perty, as already seen, retains this species with *Actinophrys*, with the name of *A. Stella*.

Genus PODOPHRYA (XXIII. 34–37).—The members of this genus differ from *Actinophrys* only in being stalked. Stalk single, not branched. Ehrenberg described them as Enchelia devoid of vibratile cilia and teeth, with spherical bodies, covered with setaceous tentacles; having a truncated (direct) mouth; and in organization equivalent to *Actinophrys*, with a stiff stalk.

PODOPHRYA *ovata* (Alder). — Body ovate, with a very slender and short stem; tentacles capitate, retractile, in a single row, less numerous than in *Ephelota apiculosa*, and forming a narrow disc. Parasitic on *Sertulariæ*.

P. *pyriformis* (Alder). — Body pear-shaped, or rather campanulate, with a distinct rim around the summit, and a single circlet of delicate, capitate, retractile tentacles; stem long and slender. Parasitic on *Paludicella*, and, unlike the preceding, an inhabitant of fresh water.

These two species were first described by Mr. Alder, along with *Ephelota apiculosa*, and were described in the previous edition of this work, under the name of "Alderia." Lately, however, Mr. Alder wrote to inform us that this name had been applied to a different class of animals, and therefore could not be retained. Dr. Strethill Wright has since studied these beings, and distinguished one as *Ephelota apiculosa*, and placed the other two among *Podophryæ*. Mr. Alder (*A. N. H.* 1851, vii. p. 427) recognized their relation to *Acinetæ*, and their affinity to Campanularian Zoophytes, between which and Infusoria he considered them the most perfect link known.

P. *fixa* (*Trichoda fixa*, M. *Actinophrys pedicellata*, D.).—Body spherical, turbid, whitish, with a diaphanous pedicle slightly excised at the extremity. The rays or tentacles are capitate at the extremity, and equal in length the diameter of the body. Ehrenberg states that the seizing or catching power of this animalcule is very interesting to observe. So soon as a quickly-vibrating

Trichodina Grandinella approaches to, and comes in contact with, its tentacula, it is immediately taken prisoner, ceases to vibrate, and stretches out its cilia backwards. On the whole, this species resembles *Acineta*; but Ehrenberg supposed it to possess a discharging orifice, though its situation is unknown. Found among dust-like matter upon the surface of pond-water, "and perhaps," says Ehr., "also in the sea." Diam. 1-430".

P. *libera* (Perty).—Stemless, spherical; colourless, or faint yellow; periphery smooth; tentacles hyaline, pointed in greater or less number, many very long, sometimes very few present, many seen curved. Diam. 1-330". In stale pond-water.

Claparède and Lachmann have recently (*Ann. d. Sc. Nat.* 1857) distinguished a number of species of *Podophrya*, many of which would be accounted *Acinetæ* by Stein; however, they have no capsule like members of that genus. No characters are given. The following are noted:—1. *Podophrya Cyclopum*, parasitic on *Cyclops* and Lemnæ; 2. *P. Carchesii*, on *Carchesium polypinum*; 3. *P. quadripartita*, the same as the *Acineta* assigned by Stein to *Epistylis plicatilis*; 4. *P. Pyrum*, a large form, pear-shaped, found on *Lemna trisulca*; 5. *P. cothurnata*, the diademiform *Acineta* of Stein; 6. *P. Ferrum-equinum*, the *Acineta* of the same name of Ehr.; 7. *P. Lyngbyei*, the *Acineta Lyngbyei* (Ehr.); 8. *P.* ——, a marine form, with extremely dilatable suckers.

Genus DENDROSOMA (Ehr.).—This includes beings which resemble *Actinophrys*, supported on a branching pedicle. The base of the thick pedicle or trunk is fixed; and its divisions bear the animalcules at their extremities. In appearance, therefore, it resembles a microscopic Sertularian polype.

The question may be raised, if this genus is not the same as *Anthophysa* (p. 500), misinterpreted in structure; and if the organisms terminating the branches are not *Uvellæ* instead of *Actinophrydes*.

DENDROSOMA *radians*. — Corpuscles (animalcules) conical, furnished with tentacula; disposed on a soft, smooth, and alternately branched stem. At Berlin.

Genus EPHELOTA (Wright).—Similar to *Podophrya*; but the tentacles, instead of being capitate, are pointed, and form a wreath or circlet. They seem also to be either slightly contractile or retractile, or only flexible. Pedicle composed of a cortical matter or integument, and a medullary or contained substance.

EPHELOTA *apiculosa*.—Body vase- or cup-shaped, expanded at top and set round with several circlets of numerous pointed tentacles; abruptly thickened towards the base. The tentacles, which are always in more than one row, enjoy little motion, curve themselves forward occasionally, and are slowly retracted at times. Pedicle stout. Found parasitic on *Sertularia*; by Dr. Wright on *Coryne*.

It differs from *E. coronata* in having the body wider than the stem, more cup-shaped and elongated, and the tentacles more irregular, soft, retractile, and unsupported by the solid matter which occurs in the interior of those of the species named. It is especially distinguished by the shape and structure of the stem, which is of nearly equal diameter throughout, and encloses a cortical substance formed of circular fibres passing at right angles to the fibres of the medulla, which cortical fibres are absent in *E. coronata*.

E. *coronata* (Wright).—Body consists of a short cylinder of densely granular sarcode, slightly enlarged above and below, so as to resemble the circlet of a crown. It is surmounted by a circle of thick, acuminate and radiating tentacles, which are capable of being slowly curved inwards, but cannot be contracted. They remain stiffly extended when the animal is immersed in alcohol. The structure of the tentacles, I believe, is unique. Under high microscopic power they are seen to consist of a bundle or framework of fine parallel rods of horny (?) texture, imbedded in soft contractile sarcode. The more central rods of the bundle protrude continually beyond those exterior to them, so that the point of the tentacle is formed of only a very small number. In other examples, each rod, under a power of 800 diam., assumed a bearded structure.

"The animal secretes beneath itself, or from its base, a pedicle of diaphanous and colourless substance, which increases in length and breadth with the increasing growth of the animal, until it assumes the form of a glassy club, on the thick upper extremity of which the animal is seated. The whole of the pedicle is covered by a growth of scattered hairs; but it may be doubted whether these have any organic connexion with it, and whether they do not belong to one of those minute classes of Algæ the structure of which eludes microscopic research. A longitudinal fibrous structure is faintly seen in the axis of the pedicle, but it gradually disappears towards the periphery. After immersion in spirit, this fibrous structure becomes much more apparent. The action of the spirit also causes a fine membrane to separate from the surface of the pedicle, which appears to be continued downwards from the body of the animal, and is probably analogous to the membrane which I have already shown to exist as a lining and covering to the cell of *Vaginicola valvata*, and which secretes and hides within itself the valve that closes the cell of that curious animal" (*Edin. New Phil. Journ.* 1858, p. 7).

This species was twice seen by Dr. Wright, "each time in large colonies, situated within the mouth of shells inhabited by the hermit-crab, where the dense white bodies of the animalcules, seated on their transparent pedicles, form sufficiently remarkable objects."

Genus ZOOTEIREA (Wright) (XXXI. 14–15).—Body furnished with numerous contractile acuminate rays (tentacula); elevated on a contractile pedicle. Rays becoming thickened towards the point when not fully extended, but not capitate.

ZOOTEIREA *religata* (XXXI. 14–15).—The body of the animalcule, when contracted, consists of densely granular sarcode surrounded by a layer of more transparent substance. This external coat is capable of being prolonged into innumerable exceedingly attenuated tentacles or rays, from eight to ten diameters of the body in length, and resembling in structure those of *Ephelota apiculosa*. The animalcule is elevated on a long contractile pedicle, which appears also to be continuous with the external coat of the body. I have several times seen this animal, always in colonies. When seen by oblique illumination, it has a very striking appearance. The light reflected from the rays has the appearance of two cones issuing on opposite sides of the body, and rotating in opposite directions with every movement of the lamp. Found on shells dredged from deep water in the Firth of Forth.

We are indebted to Dr. Strethill Wright of Edinburgh for the knowledge of this genus and species. Dr. Wright was so kind as to transmit the account to us in manuscript, together with notes on *Ephelota*, the characters of the following peculiar genus *Corethria*, and those of several additional Infusoria.

Genus CORETHRIA (Wright) (XXXI. 5, 6).—The history of this genus is thus described (*in literis*) by its discoverer, in the details of the structure of the only species yet found, viz.:—"*Corethria Sertulariæ* consists of a body, or oblong cushion-like mass of granular sarcode, furnished with a long club-shaped appendage, which bears at its summit a thick brush of tentacles. The body is generally homogeneous, although occasonally one or two large cells are seen within it. The mop-like appendage is seen to contain two structures, both without granules. The interior or medullary portion is a transparent and structureless cylinder, arising from a slight depression in the body of the animal. The exterior structure, also transparent, is transversely wrinkled or rugose. The tentacles are transparent, from eight to about forty in number, and have occasionally a slight waving motion: they appear to arise from the internal lamina or core of the mop. A second kind of appendage is frequently found attached to the body of *Corethria*, in the form of a long spindle-shaped mass of granular sarcode, similar to the body, having a depression, perhaps an orifice, at its distal end. This is either a parasite or a gemma, as it is sometimes found attached alone to the *Sertularia*. It appears to multiply by fission, as two are sometimes found attached together."

In another letter, Dr. Wright remarks that he has "doubts as to the *Gregarina*-like body being a part of the animal, as it is often absent," and he has "seen it fixed to neighbouring bodies." Food is probably taken up by the summit of the mop-like process, absorbed, and carried down to the body.

Dr. Wright has found this remarkable animalcule three successive years at Granton, in great abundance, though in a limited locality. It occurs at all parts of the polypidom of the *Sertularia pumila*, but chiefly in the angle between the mouth of one cell and the lower part of the cell above, where two or three sometimes nestle together.

Although unlike all other animalcules in shape, Dr. Wright is induced by its structure to place it near *Actinophrys*. Were it not for the cushion-like body, the mop-headed process would be referable to *Ephelota*.

Subgroup ACINETINA. (Part I. p. 258.)

(Plates XXIII. 1–27; XXVI. 3–4; XXVII. 13–15, 18–20; XXX. 3, 4, 8, 21–23.)

A subclass of Rhizopoda, very closely resembling Actinophryina, but covered by an integument or capsule, through which the retractile tentacula or filaments are protruded, and usually supported on a pedicle.

The *Acinetæ* have been supposed to have no power of nourishing themselves by absorption of foreign matters from without, as do the Actinophryina; but this seems to be an error; and Lachmann asserts them to be peculiarly carnivorous animals, the prey being seized by the tentacula, which have suctorial extremities.

The researches of Stein went to show that the members of this family were nothing more than a developmental phase of Vorticellina; but, although this view has been accepted by a few naturalists, it has been pretty successfully controverted by Lachmann, Claparède, and others, who have witnessed the reproduction of *Acinetæ* from parent forms.

The tentacles of Acinetina are not as a rule capitate; many taper, others are of nearly the same width throughout. They may be distributed pretty generally over the body, or only along a certain margin, or, again, may be collected into several bundles.

To represent the known specimens of Acinetiform beings, we shall describe all those varieties described by Stein; for the truth or error of his hypothesis of transformation does not affect the value of his descriptions of them as distinguishable forms of organized beings. But before entering on the account of these, we shall reproduce the species enumerated by Ehrenberg under the head of *Acineta*.

Genus ACINETA.—Has a membranous lorica, a simple pedicle, and numerous retractile, non-vibrating tentacula. Ehrenberg notes his discovery of vesicles (stomach-cells) in *A. Lyngbyei* and *A. mystacina*, and of a nucleus in the latter and in *A. tuberosa*. Self-division not observed. Reproduction by germs, noticed by Stein, Cienkowsky, Lachmann, and others.

ACINETA *Lyngbyei*.—Spherical, pedicle thick. It resembles a stalked *Actinophrys*, while the circular, radiating, pale-yellow coloured body, with its thick crystalline stalk, is similar to a retracted *Vorticella*. On *Sertularia* and other

Polypes. This is called a Podophrya by Lachmann. Length, including stalk, 1-170" to 1-100".

A. *tuberosa* (*Vorticella tuberosa*, M.) (XXVI. 3–4).—Triangular, compressed; dilated and truncate anteriorly, with three obtuse tubercles or horns, of which the two lateral are more constant, and furnished with tentacula. Pedicle simple and slender. 1-210" to 1-100". In marsh- and sea-water; on *Ceramium diaphanum* (XXI. 3–4). See account of *Acineta* of *Zoothamnium affine*.

A. *mystacina* (X. 205).—Subglobose, obtusely horned, with two elongated bundles of tentacula; pedicle slender. Upon *Lemna minor*. 1-860" to 1-120".

A. *Ferrum-equinum* (XXIII. 26, 27).—Ovate, white, tentacula disposed at its front; pedicle small, thick; a central gland of a horse-shoe shape. 1-240". Berlin. This Lachmann calls a Podophrya.

A. (?).—Brightwell describes an animalcule with an oval sheath, of a dark colour, opake and granulated, and having a bundle of diverging rays proceeding from each extremity, many of which, by contraction or otherwise, have a globular tip. They were not observed to move or catch other animalcules. In fresh water at Oulton, Norfolk.

A. *patula*.—A species mentioned by Lachmann (*A. S. N.* 1857) as developing embryos, and common on Algæ and *Zostera* found on the coast of Norway.

A. *Cucullus*.—Another species named, and not described, by the same naturalist. Found in the Fjord of Bergen.

A. *cylindrica* (Perty). — Colourless, transparent, cylindrical, supported on a short stem. 1-22'''.

Cothurnia maritima. — Its presumed *Acineta* bore a close resemblance to *Acinata tuberosa* (Ehr.). It had a moderately long, thin stalk, not dilated upwards; and the body was enclosed by a hyaline capsule, capped by a conical, roof-like portion, from which the inverted conical or pyriform granular body was suspended, more or less space intervening between it and the capsule. From each external anterior angle proceeded a bundle of gently-tapering, fine, and slightly capitate tentacles, retractile and divergent. Internally was a round contractile space and an oval nucleus.

Epistylis branchiophila. — The *Acineta* assigned to it by Stein has usually a short, slightly curved, stiff and solid pedicle, always much thinner than the stem of the *Epistylis* itself. Figure pyriform; two bundles of bristly, non-capitate tentacula given off from its anterior end. The body exhibits constant changes in outline by the vermicular contractions of its tissue, and likewise alters its relative position with its stem. It likewise exhibits transitory folds, swellings, and inflations of the surface. 1-240".

E. crassicollis.—Stem of its *Acineta* transversely striped, crystalline, mostly straight, and generally like that of the *Epistylis* itself, except in thickness, being in this respect much thinner, save at its expansion, supporting the body of the *Acineta*. This last is of a rectangular figure, with rounded angles, and often inflated at the middle. Tentacula tapering, capitate, always few in number—from two to four at each of the four angles, and always longer than the diameter of the body. Length (maximum) of body 1-30''', breadth 1-28'''. Found on the Entomostraca.

E. plicatilis. — *Acineta*-pedicle solid, longitudinally striated, much narrower than stem of the *Epistylis*, except at its upward dilatation, where the body was affixed. Body pyriform or ovoid, compressed; in most specimens with a smooth surface and no tentacula: when the last were present they were small, capitate, and few in number, and collected in four bundles, one on each lobular expansion of the then expanded *Acineta*. Maxim. length 1-16''', width 1-20'''.

Opercularia articulata (XXX. 3–4).—Pedicle of *Acineta* rigid, solid, thin, mostly curved, and shorter than the body. After a certain height (about the half) it suddenly and greatly expands to its point of articulation with the body. It is striated longitudinally, and hyaline. Body compressed, with a circular outline, or discoid, ovoid, or pyriform figure. Abruptly and widely truncate at its base, where it is fixed on its pedicle: surrounded by an apparently firm and thick integument, without aperture, and covered at slight intervals by short, thick, tubular and undulating tentacles. Maximum length 1-20''' to 1-12''', width 1-14''' to 1-24'''.

O. berberina (XXIII. 17–20).—Stem of *Acineta* very short, thick, solid, smooth or transversely striped, usually contracted in the centre and dilated at each end. The stem supports a very large, flattened, discoid capsule, with a parabolic outline, and having a gently curved anterior double margin enclosing an open space. The margins are comparable to a front and back lip: the walls of the capsule thick, flexible, and hyaline. A portion of the contained *Acineta*-body extends beyond the lips like a tongue. This process contains from four to five contractile spaces, variable both in position and size, as well as changeable in figure, from a circular to a dumb-bell shape. The rounded anterior angles of the process support numerous radiating tubular tentacles, neither capitate nor tapering, but retractile and capable of being collected together in cylindrical bundles. The tentacles may be retracted within the lips of the capsular opening; and when this happens, the anterior margin of the *Acineta* has a trilobate character; and very frequently a transverse fold makes its appearance behind the middle of the body, and might easily be mistaken for an indication of commencing transverse fission. Sometimes two such folds are displayed. Maximum length of capsule 1-14''', width across the anterior labiate extremity 1-19'''; length of pedicle 1-125'''.

In figure and other respects this *Acineta*, remarks Stein, differs so materially from those of other Acinetina, that, if these beings are to be considered independent organisms, it would require the creation of a new genus.

O. Lichtensteinii (XXIII. 22-23).—The *Acineta* varies very much both in figure and dimensions. All varieties have a short, thick, solid stem, dilating upwards to the body of the animal. When largest, it equals half the length of the body, but is at times so short that the body seems as if sessile. The body is usually strongly compressed laterally, and in outline is a long or short oval, ovate, pyriform, or circular, except that in all cases it is narrowed at its base to equal in width that of the supporting pedicle. In short-stalked smaller individuals, the body is mostly so very shortened and depressed, in its long axis, that the stem is quite overlaid, and the entire being has a reniform shape. A circular or oval nucleus occurs in the interior, but no contractile sac was discoverable. Maximum length 1-18''', width 1-24''', diameter of smallest specimens 1-96'''.

Ophrydium versatile (XXX. 8).—Stein does not appear satisfied with regard to the Acinetiform being to be assigned to this member of the Vorticellina (Ophrydina). He found many cystic oval or ovoid bodies, with an irregular central nucleus and numerous chlorophyll-corpuscles in company with this *Ophrydium*; and along with these, which he concluded to be encysted beings, other saccular organisms, of like size and figure, containing also a central nucleus and many chlorophyll cells, and withal furnished with a large number of tapering tubular, mostly curved or contorted, motionless processes or tentacles, distributed over the surface, recalling, in general appearance, the "digitate *Acineta*."

Spirochona gemmipara (XXX. 21-24).—Stein assigns to this peculiar member of the Vorticellina a very extraordinary *Acineta*, which he has named *Dendrocometes paradoxus*. The body is plano-convex, circular, without pedicle, and gives off from its surface no tentacles of any of the ordinary types, but one or more large tubular processes, more or less branched. There is so great an inconstancy in the number, position, size, and ramification of these processes (says Stein), that two similar specimens are scarcely to be found. The processes on the same being differ also very much in size and mode and degree of branching. Five is the prevalent number in the most fully developed forms; above six are scarcely ever seen; three or four are not uncommon; a single one is seen only in undeveloped examples. An entire absence of such appendages is not very uncommon, the nuclear developments in their interior serving to identify them. Neither their trunk-like process nor any of its ramifications has the power of lengthening or shortening itself; but the whole process may undergo a certain amount of curvature, and extend itself in a rigid manner. Diameter of body 1-54''' to 1-25'''.

Notwithstanding the very patent diversity in form and constitution, Stein declares these tubular ramified processes to be morphologically and physiologically identical with ordinary tentacula.

Vaginicola crystallina (XXVII. 12-15).—The *Acineta* attributed to this being by Stein has a hyaline capsule, expanded in front and narrowed posteriorly into a sort of hollow pedicle. The dilated upper portion is infundibuliform, urceolate, or pyriform in figure, and is partially occupied by the granular mass of the body of the animalcule, enclosed in a membranous sac of its own. The body is suspended from the vaulted anterior surface of the capsule by an intermediate gelatinous layer, which often appears plicated. Its bulk varies extremely; at times it nearly occupies the whole cavity of the capsule, except the prolonged stem-like portion, which never contains any; at others it forms only a small ball at the anterior end, which is then contracted upon it by being thrown into a few longitudinal folds. The tentacles proceed from the anterior surface of the body and penetrate through certain fissures in the capsule above, diverging from the surface in a radiating manner. They are long, capitate, slightly tapering and retractile. The body contains a circular nucleus and a contractile vesicle. Maximum dimensions of capsule 1-4‴ in height, 1-32‴ in width. The minimum 1-24‴ high, and 1-43‴ wide.

Stein puts this *Acineta* forward as one of the best illustrations to be obtained of the conversion of an encysted Vorticellina into an *Acineta*. The *Acineta* he identifies with the *A. mystacina* (Ehr.), and portrays two modes of development: one by a series of ciliated embryos, enveloped each in its own capsule, given off from the surface by a sort of gemmation—this process going on until the whole animal mass is exhausted; the other by the conversion of the whole mass, simultaneously, into several elongated-oval granular germs, covered by a membrane, but not ciliated.

Vorticella microstoma.—Stein considers the *Actinophrys Sol* and *Podophrya fixa* (Ehr.) to be the Acinetiform representatives of this species of *Vorticella.* In our opinion, as before expressed, and which we partake in common with Cienkowski and others, the being described by Stein under the name *Actinophrys* is in fact an *Acineta.* It is represented as covered by a firm integument, which frequently assumes the characters of a cyst, becomes plicated around it, and extended into a hollow pedicle, giving it the appearance of *Podophrya.* Moreover, foreign substances were never seen to enter its interior, as happens in the true *Actinophrys.* The further history of this *Acineta* has been sketched in the chapter on development of Ciliata (p. 360 *et seq.*).

V. nebulifera.—The *Acineta* in Stein's estimation belonging to this species of *Vorticella* is found upon Lemna. The pedicle is much longer and the body more contractile, and therefore more changeable in figure, than the *Acineta* found on the *Cyclops.* When at rest, their figure is more or less compressed, and ovate or pear-shaped, with a prominent angle on each side of the anterior margin, from which a bundle of radiating retractile tentacles extends. Oval, circular, and discoid forms are not uncommon. The stem is elastic, curved, and, as a rule, longer than the body it supports, and is hollowed by a narrow canal. It expands at its junction with the body and then spreads over it, forming an external sheath or capsule, except in the region supporting the tentacles, where it seems to be either absent or of great tenuity. Beneath this is a special covering of the *Acineta* body, entirely investing it. Notwithstanding these coverings, the body is remarkable for its contractility and the mutability of its figure. It also enjoys a certain amount of movement on its pedicle, bending in this and that direction with a peculiar jerking motion. The body contains an oval nucleus, and from one to three contractile spaces. It developes a ciliated embryo. The length of the body is from 1-100‴ to 1-20‴, that of the stem not above 1-10‴.

Zoothamnium affine. — The supposed *Acineta* of this animalcule was found by Stein on marine Crustacea—the *Gammarus marinus* and *Sphæroma serrata,* along with the *Zoothamnium.* It appears identical with the *Acineta tuberosa* (Ehr.). It is compressed, campanulate, or pyriform, and has each external anterior angle lobate and surmounted by a group of tapering and radiant tentacula. An intermediate prominence is also frequent, but no tentacles spring from it. The body is distinctly enclosed by a hyaline elastic capsule, which is extended downwards into a tubular pedicle, and by a softer membrane immediately investing it. The latter becomes especially pronounced when, as frequently happens, it is thrown into transverse folds in its narrower or posterior half during the more forcible contractions of the body. Length from 1-63‴ to 1-24‴; maximum of stem 1-18‴.

Carchesium pygmæum. — Stein latterly referred to this species an *Acineta,* common on *Cyclops,* and which he at first assigned to *Epistylis digitalis.* The stem is very short, often with difficulty perceptible, but never wanting. The body is generally pyriform and compressed; its anterior end is rounded or truncate, and slightly emarginate, and supports at each of its angles a bundle of tentacles. Frequently the tentacula are not thus grouped in two masses, but occupy the whole anterior margin and the sides for a short distance—a circumstance met with in smaller specimens which have a circular, oval, or reniform figure. The nucleus is oval and small. No movements in the body are discernible, and the lengthening and shortening of the tentacles is very slow. This *Acineta* developes a ciliated embryo which resembles the *Halteria Grandinella* (Duj.). Maximum length 1-30‴. Common size, diameter 1-50‴ to 1-40‴.

ACINETA *diademiformis* (XXIII. 15-16).—Stein describes a peculiar *Acineta* found upon the roots of Lemna, under the name of the diadem-like *Acineta*. Its figure is compressed, disciform, transversely oval or reniform; and it is supported on its somewhat contracted base by a short, thick, solid stalk, longitudinally striated, and often marked by a few transverse lines. The stem is always so short that the body looks as if sessile. The latter is enveloped by a thick, structureless, smooth and hyaline external membrane, and by a second layer beneath, closely investing the animal mass. On the free margin of the body, particularly in front, a number of comparatively thick but fine-pointed tentacles are disposed at slight distances from one another. These, which are not clearly capitate, consist of a delicate membrane enclosing a finely granular matter, and are prolongations from the special membrane of the body; consequently they have to perforate the outer envelope; and Stein leans to the opinion that the latter is an excretion from the former. Usually the tentacular processes are very slowly retracted: however, when the *Acineta* is much disturbed, the shortening takes place much more rapidly, and renders them tortuous. A long band-like nucleus lies across the centre; and a number of transparent vesicles are disposed at equal intervals around the border, like a row of pearls around a diadem. At long intervals one or another of these sacs is seen to vanish, and after a time to reappear in the same place, like true contractile vesicles. No contractions of the body are observable; it remains stiff and motionless. It produces a large ciliated embryo, which lies transversely across it in its special sac. Maximum breadth 1-14‴; height 1-20‴, of stem 1-100‴.

The stiff solid stem and the remarkable band-like nucleus indicate, says Stein, its derivation from some large species of *Epistylis*. It is the same organism as the *Acineta Ferrum-equinum*, according to Lachmann.

A. *digitata* (XXIII. 21).—Under the name of the fingered or digitate *Acineta*, another variety of this class is characterized by Stein, who failed to detect the ciliated Infusorium to which, according to his hypothesis, it should owe its origin. It was found on some Entomostraca, and had a stemless, patella-shaped or transversely oval body, adherent either by the whole surface in apposition or by the central portion only. Its upper side usually presented irregular depressions and small eminences, and was very often divided into an anterior and posterior half by an annular constriction. From the entire upper surface, or only from its anterior section when the central constriction is present, a number of divergent, very thick, finger-like tentacles spring, apparently without order and non-retractile. No contractions of the body were witnessed; but some change of outline is possible. A narrow, coiled nucleus is brought into view by acetic acid. The peculiar contractile vesicles are wanting; but from two to three unchangeable clear spaces of different sizes exist. Along with these normal specimens, others occurred having a smooth surface and no processes. Maximum width 1-30‴; height 1-58‴.

Genus OPHRYODENDRON.—Noticed and named in Lachmann and Claparède's paper in the *Ann. d. Sc. Nat.* 1857. No description given.

It is said to be a very singular animal, doubtfully referable to Acinetina, found parasitic on Campanularia from the Norwegian coast. One species is named.

OPHRYODENDRON *abietinum*.—Characters undescribed.

GROUP III.—CILIATA (p. 199 and p. 266).

THE group of the ciliated Protozoa, according to the scheme adopted, are resolved into two divisions:—1, mouthless (Astoma); and 2, those having a mouth (Stomatoda). Of the former we have in the general history described two familes, viz. Opalinæa and Peridiniæa; and we shall first proceed to give a systematic account of their several recognized members, and in so doing redistribute certain species and genera otherwise classed by Ehrenberg,—for instance, several *Opalinæ* described among the *Bursariæ*. Again, in the systems of Dujardin and Perty, several mouthless genera are enumerated which must find their place in the first division of the Ciliata, as adopted by us. Such are the Leucophryina of Dujardin generally, together with a few Plœsconiens and Erviliens, and the Cobalina of Perty. The Peridiniæa of Ehrenberg, again, include two genera, *Chætotyphla* and *Chætoglena*, which should rightly find a place among Phytozoa; but, to avoid disturbing the classification employed, we have retained them in the same family.

Among the Stomatoda are described, not only the families enumerated by Ehrenberg (see p. 377), but also those constituted by Perty, Dujardin, and others,—the place of their introduction being determined by the Ehrenbergian group to which they appear to hold the greatest affinity.

We commence the systematic account of the Stomatoda with the ill-defined and imperfectly observed family Cyclidina, and take the other Ehrenbergian families in the order shown at p. 377. With the Vorticellina the Urceolarina of Dujardin and the Vaginifera of Perty are conjoined, as well as several genera newly instituted. The Ophrydina embrace additional genera; and the genus *Enchelia*, whilst it is, on the one hand, deprived of the very heterogeneous organisms introduced into it by Ehrenberg, viz. *Actinophrys*, *Acineta*, and *Trichodiscus*, and which have already been treated as subfamilies of Rhizopoda, it has, on the other, appended to it the families Tapinia, Apionidina, and Holophryina of Perty, besides several genera named by this naturalist and by Dujardin. The history of Bursarina, Decteria, and Cinetochilina (Perty), is included in that of the Trachelina; and that of Paramecina (Duj.) and Aphthonia (Perty) in the account of Kolpodea. The Oxytrichina embrace the Keronina (Keroniens) of Dujardin; lastly, the Euplotina comprehend the Plœsconiens and Erviliens of the same writer.

Division A.—ASTOMA.

FAMILY I.—OPALINÆA. (Part I. p. 267.)

(XXII. 46, 47; XXVI. 28, 29.)

Ciliated parasitic Protozoa, consisting of a more or less oval sac, which resemble in figure many *Bursariæ*, and, although often presenting an anterior fold or fossa, have no mouth. They contain, besides the usual molecular matters, a granular nucleus, and multiply by transverse fission. A globular contractile vesicle is absent in all; but in *O. Planariarum* and *O. uncinata* (of Schultze) an elongated pulsating sac occurs, recalling in character the so-called dorsal vessel of various higher animals; and in others, instead of a contractile vesicle, numerous irregularly-disposed saccular spaces occur. The nucleus is not discoverable in *O. Ranarum*, whilst in *O. branchiarum* one of unusually large volume is found. *Opalinæ* are probably larvæ of various vermes, and not independent organisms.

Genus OPALINA.—The characters the same as those of the subclass. It will be seen, in the following specific descriptions, that many of the *Opalinæ* have been described by other systematic writers as members of genera of Stomatoda, such as *Bursaria*, *Leucophrys*, and *Paramecium*. Stein has devoted much attention to the *Opalinæ*; and we accept his determination of the characters and distinctions of species, along with the names he has assigned them.

The genus *Opalina* was constituted by Purkinje, and has been generally accepted. Dujardin introduced *Opalina* into his family Leucophryina along with *Leucophrys* and *Spathidium*, and characterized that family as of a compressed-oval or oblong figure, clothed with closely-arranged cilia in regular series, and apparently destitute of a mouth.

OPALINA *Ranarum* = *Bursaria Ranarum* (E.).—The mouth described by Ehrenberg in this species is merely a fold of the surface, as may be proved by adding a dilute solution of iodine, of alcohol, or of acetic acid, which will cause the animal to swell up and evenly distend the entire surface. Stein could find no nucleus. This species is common in the intestine and bladder of frogs. Perty makes it to include besides *Bursaria Ranarum* (E.), also *B. Entozoon*, *B. Nucleus*, and probably *B. intestinalis*.

O. *Planariarum* (Siebold) = *O. polymorpha* (Schultze). —The body has the form of a long cylindrical sac, pointed and wedge-shaped posteriorly, and expanded in front as a remarkable semicircular disc, by the central part of which it adheres to the surface of the intestine it occupies, the border being crowned with a wreath of long cilia. The actual point of attachment appears destitute of cilia; but the posterior surface is thickly studded with shorter ones. The contents consist of a homogeneous molecular substance, with numerous interspersed hyaline spaces. A long pulsating vesicle (or, from its length, a vessel) and a nucleus are also seen within the interior. The pulsating vessel extends to the extreme point of the body behind, just beneath the integment, but not in union with it, and terminates on the anterior side of the semicircular process in front. Its walls are structureless and transparent; and by its alternate contractions and expansions it pushes forth the contained water alternately from each end. The position of the nucleus in the interior is not constant; it consists of a finely granular mass containing some larger granules, and is sharply defined. Fission is transverse, the nucleus and contractile vessel dividing consentaneously with the body. Stein could not discover the orifices at the end of the pulsating vessel described by Schultze. Maximum size 1-3‴ in length; breadth 1-20‴; length of nucleus 1-25‴.

O. *Lumbrici* (Stein).—Is represented by *Leucophrys striata* and *L. nodulata* (Duj.), the latter being an altered form of the former, dependent on irregular endosmosis of the water in which it is placed. Transverse fission occurs in all sizes, which vary from 1-60‴ to 1-14‴. Parasitic in earth-worms (*Lumbrici*).

O. *armata* (Stein) = *O. Lumbrici* (Duj.).—Has an oval compressed figure like the foregoing, from which it differs by having a strong, horny, uncinate process at the anterior extremity, on the under surface of the body, and, extending from it, a fold of the surface. The otherwise homogeneous and finely granular nucleus is remarkable by exhibiting a greater or less number of solid oval nuclei and elongated rods. Specimens of this species are peculiar by their uniformity of size, which somewhat exceeds that of the largest *O. Lumbrici*, being from 1-12‴ to 1-8‴: hence Stein presumes that *O. armata* is nothing more than a further developed phase of *O. Lumbrici*, from which it differs only in size and in the presence of the prehensile apparatus. He surmises further that this and other *Opalinæ* may be members in the chain of development of worms.

O. *Anodontæ* (Stein) = *Leucophrys Anodontæ* (E.).—Mouthless, oval, turgid, transparent; ciliated equally throughout. 1-36‴. Parasitic in *Anodonta* and *Mytilus edulis*.

O. *branchiarum*.—Is characterized by its very large nucleus, which equals in volume the half of the entire organism. Its contour is also similar; and it might be taken for an imprisoned animal. Common in the ovisacs of *Gammarus Pulex*.

O. *lineata* (Schultze). — Is without uncini, and has, like the last, a very large nucleus. In *Naïs littoralis* (see Schultze's work *Beiträge zur Naturgeschichte der Turbellarien*, Greifswald, 1851, p. 69).

O. *Naïdos* (Duj.) (XXVI. 28, 29).—Is, like the preceding, unfurnished with a prehensile apparatus. Figure oval, or very elongated and nearly cylindrical, longitudinally and transversely striated: the fold extends from the anterior extremity nearly to the middle. Numerous clear spaces in the interior, irregularly distributed. 1-22‴ to 1-11‴. Parasitic in *Naïs* (one of the Annelida) (XXI. 28, 29).

O. *uncinata* (Schultze). — Resembles *O. Planariarum* in general organization; it has the same sort of pulsating vessel, and a similar nucleus; it multiplies by transverse fission, and differs from all other known *Opalinæ* by having a pair of strong, horny uncini at the anterior extremity, one on each side of the median line, giving it a bilateral character. Stein supposes this armature replaces the usual fringe of cilia, in the animals after having attained a certain age or stage. In the interior of *Planaria Ulva*, &c. 1-120″.

O. *Tritonis* (Perty).—Discoid, rounded in front, with a loop-like depression; colourless. 1-336″. Revolves on its shorter axis. Parasitic in the intestine of *Triton cristatus* (the crested Water-newt). Is very like *O. Ranarum*, and requires further examination.

O. Nucleus = *Bursaria Nucleus*; *O. Entozoon* = *Bursaria Entozoon*; *O. intestinalis* = *Bursaria intestinalis*. These three presumed species are nothing more than different phases of growth and development of *Opalina* (*Bursaria*, Ehr.) *Ranarum*. We have, however, retained the brief notes of their characters as *Bursariæ* given by Ehrenberg.

FAMILY II.—COBALINA (Perty).

Animals parasitic; either with or without a mouth; most of them receive only the juices of other animals. Body mostly flattened, oval, elliptic, or reniform, with numerous rows of very delicate cilia, and often with an uncinate variety on the under surface. An oral-looking depression or fold furnished with stronger cilia commonly perceptible; but several have no such indication of a mouth. Only those living externally upon animals are capable of receiving solid nourishment. In internal functions and in form they present a general uniformity and agreement, and are equally peculiar; they occupy a lower position than free living forms similar to them; their movements are simply automatic in character.

a. *With rows of cilia above, and uncini beneath.*

Genus ALASTOR.—The type of this genus is the *Kerona Polyporum* (Ehr.), and is called *Alastor Polyporum*.

b. *With delicate cilia both above and beneath.* Receive only the juices of other animals.

Genus PLAGIOTOMA (Duj.) (*vide* FAMILY TRACHELINA).

PLAGIOTOMA *Lumbrici*; PL. *Concharum*; PL. (?) *difformis*.

Genus LEUCOPHRYS (Duj.) (*vide ante*, p. 570, OPALINA *Lumbrici*).

LEUCOPHRYS *striata*.

Division B.—STOMATODA.

FAMILY I.—CYCLIDINA.

(X. 209–212).

Illoricated Polygastrica devoid of eye-specks and of true alimentary canal, and having but one alimentary aperture, furnished with cilia or bristles, the various groupings and relations of which afford characters for the discrimination of the genera; gastric cells (vacuoles) have been observed in two species of *Cyclidium*. Locomotion is effected by the vibratile cilia and a filament proceeding from the anterior extremity.

The genera are distributed as follows:—

Body furnished with cilia	Body compressed—cilia arranged in a single circle	Cyclidium.
	Body round—cilia scattered all over	Pantotrichum.
Body furnished with bristles		Chætomonas.

This family has no corresponding one in the system of Dujardin. Some of its members are represented in the family of the Enchelina as members of the genera *Acomia* and *Enchelys*. The genus *Cyclidium* (Duj.) is included among the Monadina of that author (p. 497), and includes beings furnished with a filament, but destitute of mouth and cilia—characters not at all analogous to those given by Ehrenberg to his genus of this name.

Perty, moreover, has not retained this family in his system, although he accepts the genus *Cyclidium*, which he refers to a family called "Tapinia," where it is associated with *Acomia* (Duj.), with *Leucophrys* (Ehr.) or *Trichoda* (Duj.), and with the following newly-instituted genera: viz. *Acropisthium*, *Bæonidium*, *Opisthiotricha*, *Siagontherium*, and *Megatricha*,—a set of terms not recommending themselves by their euphony, and, we presume, not wanted in a true systematic distribution to express distinct and independent forms of ciliated Protozoa. However, to render our *résumé* complete, these presumed new genera are appended to the family of Enchelia, to which several of their species are referred by Ehrenberg.

The family Cyclidina (Ehr.) would, in all probability, disappear from a revised system of classification. Thus *Cyclidium* appears to be only an embryonic phase of other animalcules, and *Pantotrichum* and *Chætomonas* are not sufficiently characterized and examined by Ehrenberg to enable us with certainty to recognize them, or to determine their affinity. Moreover, the beings brought together under these genera are, some of them at least, very doubtfully referable to them, and have been so casually examined that their identification would be difficult. The ova and the polygastric organization mentioned in Ehrenberg's account are matters only of hypothesis.

Genus CYCLIDIUM.—Body compressed discoid, provided with a simple circular row of cilia. In *C. Glaucoma* alimentary vacuoles are distinct. The mouth is a rounded opening, situated upon the under surface of the body, either close at the anterior extremity, or towards the centre. The organs of locomotion consist, as in *Kerona* and *Stylonychia*, of a number of cilia-like feet, situated on the margin of the abdomen. It has been thought that longitudinal lines, produced by rows of very delicate cilia, were present; if so, and an anal opening be discovered, *C. Glaucoma* would rank with the *Oxytrichina*. Fission transverse. Since Ehrenberg wrote these observations, Lachmann has described not only a mouth, but also an anus on the ventral surface near the posterior extremity. This statement, taken in connexion with another, that some at least of the forms of *Cyclidium* are embryonic stages of other animalcules, leaves this genus in the greatest uncertainty both as to its independent existence and its systematic position.

CYCLIDIUM *Glaucoma* (M.).—Oblong-elliptic, abdomen fringed with cilia; delicate longitudinal striæ are observed upon the back. In swimming, it resembles *Gyrinus*, or *Notonecta*, a well-known little black water-beetle (see *Microscopic Cabinet*, pl. 4). Sometimes the movement is very quick; at other times the animalcules remain for a while stationary, and then presently spring with a curvetting motion to another spot. Formerly this species was confounded with *Glaucoma scintillans*, but is much smaller (x. 209 is a side view, showing the cilia; fig. 211 a dorsal view; and fig. 210 a specimen undergoing transverse self-division). They are represented as fed with indigo. Abundant in vegetable infusions in the spring. 1-2880" to 1-1150".

Betwixt this species and *Enchelys nodulosa* (Duj.) there is a complete agreement. The body, on a transverse section, is triangular; hence it is (says Perty) that Dujardin has described it as sometimes assuming a triangular form. Chlorophyll granules are occasionally seen internally. Stein identifies the embryo of *Chilodon Cucullulus* with this species of *Cyclidium*, which he would therefore exclude from the category of independent animalcules. Internally, this excellent observer also describes a contractile vesicle and a discoid nucleus; the former is the clear space mistaken by Ehrenberg for a mouth. At the same time he considers an oral aperture most probably exists somewhere near the middle of the organism, since he has seen the entrance of solid particles into the interior. Perty makes *C. Glaucoma* synonymous also with *Enchelys triquetra* (Ehr.), and probably with the *Paramecium Millum* and *Cyclidium Millum* of Müller. In his system it is a member of the family Tapinia, where it is conjoined with some species of *Leucophrys*, with *Acomia* (Duj.), and several newly-created genera.

C. *margaritaceum.*—Orbicular, elliptical; the posterior end slightly excised; the dorsal surface with distinct longitudinal lines; cilia not distinct. 1-1500″ to 1-1000″.

This species is separated by Perty from *Glaucoma*, and constitutes in his system the representative of a genus he names *Cinetochilum*, which, with *Glaucoma*, forms the family Cinetochilina (*vide* Glaucoma). The *Cin. margaritaceum* is characterized as a short elliptical animal, rather compressed and with its vibratile flap on the posterior half, colourless and transparent. Movements quick; rotation on its axis rare. Cilia very short. Fission transverse. 1-810″ to 1-720″. Lachmann (*A. N. H.* xix. 216) appears to approve of the systematic position assigned by Perty to this being.

C. (?) *planum.* — Oblong-elliptic, smooth; cilia but little marked. 1-2640″.

C. (?) *lentiforme.* — Smaller than *C. planum*, and has no distinct striæ or cilia. 1-3180″.

C. *Arborum.* — Small, suborbicular, slightly excised laterally; dorsum rugose; margin everywhere ciliated. Diam. 1-192″. Marginal cilia used in the way of feet; swims rapidly. Fission transverse. On moss of trees.

This animalcule is identified by Cohn (Siebold's *Zeitsch.* 1851, p. 273) with the embryo developed by *Loxodes* (*Paramecium*) *Bursaria*. If this be the case, it must be rejected from the list of independent species.

Genus PANTOTRICHUM.—Body turgid, covered with moveable cilia. In *P. Enchelys* gastric cells (vacuoles) are distinctly visible. Granules, green or yellow, occupy the interior. Ehrenberg says, "The absence of a double alimentary aperture is not yet proved; nor, on the other hand, is its existence." *Pantotrichum* is not received by Perty as an independent genus, but is comprehended by him with *Lagenella* and *Chætoglena*, under the common appellation *Chonemonas*, and placed among the Thecamonadina.

Pantotrichum *Enchelys.*—Cylindrical, oblong, rounded at both ends; hyaline at extremities and turbid, the centre-colour pale yellow. x. 212 is a cluster of animalcules; those to the left are more highly magnified than the others. In swimming they revolve and glide along in the direction of the longer axis of the body. In infusions of raw flesh. 1-1150″.

P. *volvox* (*Leucophrya viridis*, M.).—Ovate, spherical, of a green colour. In brackish water. 1-860″.

P. *Lagenella.*—Ovate, the ends equally rounded, anterior ciliated portion produced in the form of a neck or beak. Amongst Confervæ. 1-1080″ to 1-570″.

Schneider (*A. N. H.* 1854, p. 329) describes this species as forming around itself a cyst, which completely retains the flask-like form of the body, when the animalcule enters on a state of rest.

Genus CHÆTOMONAS.—Motion slow, and leaping by means of the bristles on the body, which are not vibratile. Internal organization very little known. They are parasites, living on the dead bodies of other Infusoria, and in infusions of flesh or other animal matters. A vibration is seen at the mouth; but whether it is produced by a filament or by cilia, is uncertain. In *C. constricta*, transverse self-division is thought to have been seen.

Chætomonas *Globulus.* — Almost spherical, of an ash-colour, furnished with setæ or bristles. It often has the figure of *Monas Guttula*, but is larger; sometimes two cluster together. In bad-smelling infusions of animal matter along with *Pantotrichum Enchelys*, *Monas Termo*, &c.; also in the dead fronds of *Closterium acerosum*, as shown at x. 113. 1-2880″.

C. *constricta.* — Transparent, oblong, slightly constricted at the middle, and having two setæ or bristles. In dead *Hydatina senta.* 1-5760″.

FAMILY II.—PERIDINIÆA. (Part I. p. 271.)

(Pl. X. 214–226; XII. 47; XXXI. 16–23.)

Infusoria without an alimentary canal, covered with a lorica, upon which cilia or setæ are often arranged in the form of a zone or crown—hence the name. The lorica has only one opening. Three out of the four genera have a filament besides the wreath of cilia around the middle of the body, or scattered cilia or bristles. In only *Peridinium Pulvisculus* and *P. cinctum* have artificial means succeeded in demonstrating the admission of food, the internal organization being greatly obscured by the mass of coloured opake granules, which Ehrenberg called ova. A nucleus and a red stigma (eye, Ehr.) are discoverable in some species.

The genera are disposed as follows:—

Lorica having stiff bristles or short spines—no transverse furrowed zone	no eye	Chætotyphla.
	eye present	Chætoglena.
Lorica smooth or rough—a ciliated transverse zone present	no eye	Peridinium.
	eye present	Glenodinium.

Some of the presumed species have been found only in a fossil state in flint.

Dujardin constitutes a family Peridiniens, agreeing in the main with that of Ehrenberg, and thus narrates its characters: "Animals without known internal organs; enveloped in a regular, resistant, membranous lorica, which sends off a long flagelliform filament, and, in addition, has one or more furrows beset with vibratile cilia."

The lorica would appear to have no opening; for foreign bodies and colouring matter are not seen to enter it. Several have their lorica prolonged into horn-like processes; and some exhibit a coloured point (eye-speck). They are distinguished from Thecamonadina by the ciliated furrow or furrows.

Dujardin observes that "as the first two of Ehrenberg's genera are without the furrow and vibratile cilia, and have only a filament as a locomotive organ, they are evidently akin to, and not separable from the Thecamonadina, unless spines or asperities of the lorica are to be taken for cilia. Again, the so-called eye-speck is not a sufficient generic distinction between *Peridinium* and *Glenodinium*; the former genus, moreover, should only include spherical animalcules, whilst those concave on one side, and exhibiting horns, will rightly form a distinct genus—*Ceratium*."

Perty coincides with Dujardin in detaching *Chætotyphla* and *Chætoglena* from the Peridiniæa, and in uniting them with Thecamonadina. *Chætoglena* he merges with *Pantotrichum* and *Lagenella* in a genus which he names *Chonemonas* (p. 513). His Peridiniæa comprehend three genera, viz. *Ceratium*, *Glenodinium*, and *Peridinium*: the first characterized by a cellular lorica prolonged into horns; the second by a cellular not-horned lorica; and the third by a structureless lorica. A reference to the figures of *Chætoglena* and *Chætotyphla* is sufficient to show that these two genera have no claim to be ranged with *Peridinium*: the former, in particular, indicates in its structure and general appearance a member of the Cryptomonadina; and the latter, if not a member of the same order, is certainly not one of the Peridiniæa, but probably the encysted state of some animalcule. The imperfect descriptions attached to these genera, and the absence of sufficiently distinctive features in their illustrations, renders their exact identification with similar known forms a matter of difficulty, if not of impossibility. Again, the special differential character between *Glenodinium* and *Peridinium*, viz. the existence of a red speck in the former, is worthless; and were no other peculiarities discoverable, the two genera should be merged into one. However, the elongation of the lorica into horn-like processes supplies a differential character sufficient at least to constitute two genera out of their several members. Ehrenberg recognized this indication of a division, and adopted it for his eyeless Peridiniæa, making two sections:—1, *Peridinium* proper; and 2, *Ceratium*, horned *Peridinia*. Perty, we have seen, uses the same structural peculiarity as a generic character, but, in addition, makes a third genus, marked by the absence of sculpturing on its lorica. This basis we hold to be insufficient for a generic distinction; and the whole of the Peridiniæa proper appear to us reducible to the two genera *Peridinium* and *Ceratium*; *Glenodinium* we would consequently cancel. The rejection of Ehrenberg's views of internal organization, and of two of the four genera he classed as Peridiniæa, renders a revised description of this family necessary. In attempting this, we may state that the Peridiniæa are animalcules having an external, condensed, chitinous integument forming a lorica, lined by a contractile membrane immediately investing the organic contents. No actual oral opening is satisfactorily made out; but in most species a deep fossa or fissure is found, from the bottom of which a flabellum extends, mostly twice or more than twice the length of the body. Their figure is more or less globular or ovate; and sometimes the lorica is extended into two or three long horn-like processes, giving the whole being a very bizarre appearance. A deep furrow surrounds the body as a zone, and in some species a vertical prolongation of it extends to one pole. These furrows are richly ciliated; yet the cilia do not appear confined to them, as Ehrenberg supposed, but may, at least in one species, cover the entire surface. The interior is occupied by masses of usually strongly-coloured brownish yellow, or reddish or greenish brown, rendering the animalcules very opake. In some species an oval nucleus has been seen; and its presence is presumable in all. A contractile vesicle has not yet been demonstrated. They multiply by transverse, and it may be also by longitudinal fission. *P. uberrimum* has been found in a quiescent condition; and doubtless some mode of propagation exists; Perty endeavours to prove it is by internal germs. The zone-like ciliary furrow may be adduced as the leading characteristic.

Genus CHÆTOTYPHLA.—Lorica silicious, hispid or spinous, destitute of a transverse furrow or zone, and of stigma; surface covered with little spines and bristles, which appear stronger at the posterior portion of the body. The lorica may be crushed by pressure, and the little creature within it be set at liberty. In swimming it revolves upon the longitudinal axis, probably by means of a delicate filiform proboscis, or of cilia at its mouth; no such organs, however, have been seen. Of the internal organization, nothing positive is known. One species has been discovered in flint, and so closely resembles *Xanthidium*, that it is often mistaken for it.

CHÆTOTYPHLA *armata*.—Ellipsoidal, brown, ends rounded; covered posteriorly with short spines, where there is a circlet of black spots, as shown in the end view, x. 215. The anterior cilia, or fine bristles, are sometimes very indistinct; x. 214 is a variety in which they are strongly marked. In clear water, amongst Confervæ. 1-620''.

C. *aspera*.—Brown, oblong, rounded at both ends, and rough, with short bristles; the little spines are scattered without order at the posterior end. Found with the preceding. 1-570''.

C. (?) *Pyritæ*.—Oblong cylindrical, rounded at both ends, and provided with delicate elongated bristles, but no spines. Fossil in flint, near Delitzsch. 1-1150''.

Genus CHÆTOGLENA.—Lorica silicious, destitute of a transverse zone or furrow, but striped or covered with spines or stiff hairs, and having an eye-speck. The organ of locomotion is a simple flabellum. The interior contains scattered transparent vesicles, and a brownish-green granular mass; a large bright spot or nucleus is also visible. Self-division not observed.

CHÆTOGLENA *volvocina*.—Ovate, with brownish-green granules, and a red eye; between the lorica and the soft body a beautiful red ring is visible in live specimens (x. 216, 218). Amongst Confervæ at Hampstead and Hackney. 1-1150″.

C. *caudata*. — Hispid, ovate, with a short tail; granules green; ocellus clear red; oral margin urceolate and dentate. 1-864″. Berlin.

Genus PERIDINIUM.—Lorica membranous, with a transverse ciliated zone; no eye. The locomotive organs are a filament and the zone of cilia. In *P. Pulvisculus* and *P. cinctum*, indigo and carmine are received, and demonstrate the formation of vacuoles, which in *P. acuminatum*, *P. fulvum*, and *P. cornutum* are visible without having recourse to coloured food. The oral aperture is found in a hollow near the centre, as in *Bursaria*. The granules are generally of a brown or yellowish-brown colour, though sometimes green or even almost colourless. In *P. Tripos* and *P. Fusus* an oval nucleus is visible. Self-division is longitudinal in *P. Pulvisculus* and *P. fuscum*; and, according to some observers, transverse in *P. Fusus* and *P. Tripos*.

The structural peculiarities are sufficiently described in the chapter on Peridiniæa (p. 271). The existence of a mouth and the entrance of food are still matters of doubt. A nucleus is probably present in all; and the same may be said of the flabellum, which subsequent observers have distinctly found in cases where it eluded the observation of Ehrenberg. "Fossil *Peridinia*," says Perty, "are not found in recent geological formations, but only in the chalk beds of the secondary strata, in which they occur with *Xanthidia* (Ehr.) and *Pyxidiculæ*."

a. *Peridinia without horns*.—PERIDINIUM.

PERIDINIUM *cinctum* (*Vorticella cincta*, M.).—Nearly globular, or slightly three-lobed and smooth, with a zone of cilia; not luminous. It swims slowly, with a vacillating and rolling motion. Amongst Confervæ. 1-570."

Instead of the red zone noted by Ehrenberg, there may be only a single speck, or even it may be absent.

P. *Pulvisculus*.—Small, of a brown or greenish-yellow colour, and not luminous; almost spherical, or slightly three-lobed; a fine filament $2\frac{1}{2}$ lines longer than the body may be observed; numerous vacuoles produced by feeding on indigo. Amongst Confervæ, with *Chlamydomonas Pulvisculus*. 1-2300″ to 1-1150″.

Perty has met with specimens having a red speck.

P. *fuscum*.—Is not luminous; oval, slightly compressed and pointed anteriorly. 1-430″ to 1-280″.

P. *Monas*.—Very small, obtuse, without horns; remarkably social. Diam. 1-1728″. In the Baltic.

Perty suggests that this is merely a young stage of *P.* (*Ceratium*) *cornutum*.

P. Planulum (Perty).—Rounded, broad, rather compressed; the two segments equal. Colour brown, usually a deep tint. Under surface rather concave. 1-720″ to 1-430″. Its brown contents contract after death into a central lump. A red speck is often seen in the posterior portion. It is distinguished from *Glenodinium cinctum* by its greater width and deeper colour.

P. *Corpusculum* (Perty).—Small; segments very unequal, posterior one very short and cleft. Granular contents brownish-yellow, or red or green. An alteration in figure has been seen to ensue after death. 1-1120″. Amongst *Marchantia polymorpha*.

P. *monadicum* (Perty).—Very small; segments unequal, the posterior one much smaller; with red stigma in the line of constriction, more seldom in the hinder half. Molecules pale green. It is the smallest known example in this family., 1-1150″. In a pond on Mount St. Gothard and at Bern.

P. *uberrimum* (Allman). Nearly spherical; colour reddish-brown; nucleus well-defined, central. A secondary furrow springs vertically from the annular one, and terminates at the pole. A stigma usually present at the polar extremity of the vertical furrow. Swims actively by the aid of its flabellum, and of cilia generally disposed on the surface, and not confined to the furrows as Ehrenberg represents. Occurs in a quiescent state. 1-1000″ to 1-500″. Ponds, Phœnix Park, Dublin.

b. *Peridinia with horns.*—*Subgenus* CERATIUM.

P. (CERATIUM) (?) *pyrophorum.*—Ovate, spherical, with two little elevated points at its anterior extremity. It is very delicately areolate and granular. Fossil in the flints of the chalk formation at Berlin. 1-570″ to 1-480″.

P. (CERATIUM) (?) *Delitiense.*—Ovate, spherical; with a little stiff point near the middle laterally. Fossil in the flints of Delitzsch. 1-430″ to 1-280″. These two supposed fossil *Peridinia* and the *Chætotyphla* (?) *pyritæ* appear rather to be sporongia of Algæ.

P. (CERATIUM) *acuminatum.*—Brownish-yellow; ovate, spherical, slightly three-lobed, and having a little process at the posterior end. "I observed this species," says Ehrenberg, "in phosphorescent sea-water from Kiel, and it is very probable that the light proceeded from this animalcule. It is the smallest phosphorescent sea animalcule that is known." 1-600″ to 1-570″.

P. (CERATIUM) *cornutum* (*Bursaria Hirundinella*, M.; *Ceratium Hirundinella*, Duj. and Perty).—Greenish; not luminous; rhomboidal and rough, with one, two, or three straight horn-like processes in front, and a single one (often curved) posteriorly. 1-280″ to 1-140″.

Perty asserts that Ehrenberg has reversed this animalcule in his account and illustrations, as he has likewise done in other species of this genus; for it is the single horn which advances foremost, and indicates the anterior extremity. The same author, moreover, states that in the majority of specimens one or more red specks are to be found, generally in the posterior half, near the middle line between the large and small horns.

P. (CERATIUM) *Tripos* (*Cercaria Tripos*, M.).—Yellow, brilliantly phosphorescent; urceolate, broadly concave, smooth, and three-horned; the two frontal horns very long and recurved; the third, or posterior one, straight. Ehrenberg says, "The power of this creature to evolve light is placed beyond all doubt, as I took up nine phosphorescent drops, one after the other, from the water, and I saw in each nothing else besides a single animalcule of this species." It is rigid, and swims with a vacillating rolling motion upon the longitudinal axis. The length of the horns is not constant, sometimes being scarcely so long as the body, at other times much longer. x. 219, 220, represent an under and side view. In the sea, near Copenhagen and Kiel. 1-140″; without the horns, 1-430″.

P. (CERATIUM) *Michaelis.*—Colour yellow; intensely phosphorescent. Lorica ovate and smooth, with three short, straight horns, as shown in fig. 221. A flagellum is not visible. In phosphorescent sea-water. 1-570″. Named after Dr. Michaelis, its discoverer.

P. (CERATIUM) *Fusus* (x. 222, 223).—Yellow, intensely phosphorescent; ovate, oblong, and smooth. The two horns are straight and extended in opposite directions, producing a fusiform figure. Ehrenberg states that he has seen the cilia of the furrowed zone, and the single filament when at rest; also an opening or mouth in the lorica, near the insertion of the filament. With horns, 1-120″ to 1-90″.

P. (CERATIUM) *Furca.*—Yellow, very phosphorescent; urceolate, with three horns; two in front short, in the form of a fork; one behind longer. In phosphorescent water, at Kiel. 1-120″.

P. (CERATIUM) *divergens.*—Yellow; cordate-ovate, smooth; with two divergent frontal acute spines, dentate at the base; posterior portion attenuated, looking as if shortly horned. Diam. 1-576″. In the Baltic.

P. (CERATIUM) *macroceros.*—Yellow; habit of *P. Tripos*, but more slender, and with longer horns, which are four times the length of the body. 1-216″. In the Baltic.

P. *Tridens.*—Yellow, with the habit of *P. flavum*, *P. divergens*, and of *P. Michaelis*; surface granular, with three acute frontal horns, and its posterior portion attenuate. 1-576″. In the Baltic.

P. (CERATIUM) *macroceras* (Schrank) or *C. longicorne* (Perty) is mentioned by Perty, and does not appear quite equivalent to *C. macroceros*, to which its name is too much alike. It is the largest of all the Peridiniæa, and (says Perty) not a variety of *P. cornutum*, as Ehrenberg thought: the lorica is rather concave below, and less bent than in that species. Empty loricæ are clearly areolate, and the areolæ round. A red stigma is often seen in the posterior half. The anterior supports a single horn, and there are three behind. 1-120″ to 1-96.″

P. *arcticum* (Ehr.) resembles *P. macroceros*, but is stronger, and has its large horns all curved and three or four times longer than the body; surface rough, with little raised puncta or spines. Length of body, 1-48‴, of entire being 1-18‴. It is phosphorescent, and found at Kingston Bay, Newfoundland, with *P. Furca*, *P. Tridens*, and *P. divergens*.

P. *longipes* (Bailey).—Body triangular, rough; angles produced into very long ciliated processes, of which the two frontal ones are longest. Body crossed obliquely by a ciliated groove (XXXI. 23). St. George's Bank, New York.

P. *depressum* (Bailey).—Lorica obliquely depressed, with one large conical posterior process, and two smaller conical frontal processes; the latter separated by a deep notch. Surface granular and reticulated. Both this and the preceding species, which were found together, were doubtless furnished with a proboscis when living, and, like other marine species of this genus, were probably phosphorescent. The form of *P. depressum* is closely analogous to the embryo of Nereïs, whose curious changes were studied by Lovén (and referred to in Prof. Owen's Lectures on the Invertebrata, ed. 1843, p. 147). This account of Nereïs, and particularly the comparison of Prof. Owen's figure with the *Peridinium depressum* (XXXI. 21, 22), led Dr. Bailey to suspect that at least a portion of the forms now included in the genus *Peridinium* might be imperfectly-developed or embryonic Annelida.

Genus GLENODINIUM.—Peridinia with motile cilia placed in a transverse furrow or zone, and provided with an eye. The organization is much the same, in other respects, as that of the preceding genus. In *G. cinctum* a flabellum is seen to emanate from the middle, and to vibrate like the wreath of cilia. It is also probably present in the other species, though hitherto unobserved. The lorica is combustible. Vacuoles and fine granules are visible in all the species; the former are very distinct in *G. apiculatum*. The red speck is in the form of an elongated or horseshoe-shaped spot, and constitutes the essential character of the genus. Longitudinal self-division has been observed only in *G. cinctum*.

Although this genus is rejected by Dujardin as indistinguishable from *Peridinium*, yet Perty retains it, making its point of separation from the latter genus—which, by the way, he prefers to call *Ceratium*—consist in the absence of horns to the lorica. The red speck he ignores, equally with Dujardin, as a distinctive character. In this way Perty's *Glenodinium*=*Peridinium*, without horns, of Ehr.

GLENODINIUM *cinctum* = *Peridinium oculatum* (Duj.).—Oval, or nearly spherical; smooth; stigma large, semi-lunar, and transverse. In fresh water, amongst Oscillatoriæ. 1-570″. It is seen both with and without a red speck.

G. *tabulatum*.—Oval; yellowish-green; lorica granular and reticulate with elevated lines, but not spinous; truncate and denticulate posteriorly, and bidentate anteriorly. 1-570″ to 1-430″.

"The colour," says Perty, "is mostly brown, especially in mature specimens, and more rarely brownish-green or green. A red stigma is but rarely present."

G. (*Peridinium*) *Alpinum* (Perty).—The sculpturing of the surface is indistinct; and very frequently there are, alternately, coloured masses of granules and hyaline spaces around the border of the lorica, producing a notched appearance. 1-430″. It is probably only an Alpine variety of *G. tabulatum*, in which the lorica has not attained its perfect structure. On Mount St. Gothard, and in Lake Lugano.

G. *apiculatum*.—Oval; yellowish-green; lorica smooth, but with hispid furrows on the margin, as shown in X. 226. The stigma is oblong, and extremities obtuse. Amongst Confervæ. 1-570″ to 1-430″.

FAMILY III.—VORTICELLINA. (Part I., p. 277 *et seq.*)
(Plates XXVII., XXIX., XXX.)

Polygastrica with an alimentary canal, the extremities of which are distinct, though they approximate in consequence of its curvature (Anopisthia). They have no lorica. A few are solitary; but the majority are congregated on pedicles, which often assume elegant ramose forms, like little trees, an animalcule surmounting and terminating each branch or pedicle. These arborescent clusters are the result of imperfect self-division.

The animal organization of this family is very distinct. The entire surface of *Stentor* is covered with vibratile cilia; but in other genera they are mostly disposed in the form of a wreath around the head. In some genera, as in *Vorticella, Carchesium,* and *Opercularia,* longitudinal and transverse muscles are seen; the mouth and discharging opening, both lying in the same lateral cavity, have been demonstrated in all. Self-division takes place in all the genera, but is least frequently observed in *Zoothamnium*: when it is imperfect, not affecting the pedicle, it gives rise to branching forms. Gemmation is also frequent in most genera. From their great irritability when approached, may be presumed the existence of a system of sensation. Colouring matter is received by all the species; eye-specks are wanting.

This family affords (in form indeed rather than in structural homologies) a connecting link between the Ciliata (Polygastrica) and Rotatoria.

The following curious particulars are appended by Ehrenberg, who regarded them as indicative of an act of transformation:—

"The *Vorticella* developes a pedicle; divides (casts its exuvia); developes posterior cilia; loosens itself from the pedicle, rambles about; draws in (after shedding a second exuvia) the posterior cilia, sheds them, and firmly attaches itself, preparatory to putting forth another stalk. This cycle of phænomena is repeated again and again, and possesses high physiological interest; it is a returning circle of transformations—a return to an early condition, similar to that of a butterfly, if it suddenly lost its wings and antennæ, and again became a caterpillar, in order once more to return to the state of pupa and butterfly—or to that of an old man becoming a child, in order to run again his course of life anew." (See Part I. p. 277 *et seq.*, and p. 586.)

The Vorticellina live for the most part in sweet water, fresh or marine, attached to plants or shells, to Crustacea, to the larvæ of insects, &c. There are, however, a few *Vorticellæ* and *Scyphideæ* produced in infusions, and even in fetid ones.

This account of the organization of Vorticellina from Ehrenberg requires considerable alterations and corrections from the present state of our knowledge of these beings. In Part I. (p. 277), their organization has been largely considered; yet a few notes here may not be misplaced Any definition of the characters of the group of genera comprehended in this family by Ehrenberg would be unsatisfactory, inasmuch as some forms are included which have no sufficient affinity. Ehrenberg represents the Vorticellina as having a polygastric alimentary canal so curved that its two ends are conterminous. Now the supposed stomachs, as displayed by using coloured food, were merely vacuoles; and no continuous alimentary canal penetrates the interior, as supposed, but only a digestive tube or œsophagus of variable length, terminating abruptly in the interior by an open mouth. The ciliary apparatus of the true Vorticellina is more complex than appeared to Ehrenberg,—the head of the animalcules being terminated by a peristom or free edge, oftentimes thickened and everted, beyond which a ciliated disc supported on a very retractile and highly sensitive pedicle can be protruded. The portion of the ciliary spiral outside the vestibulum is not of equal length in all Vorticellina: in many, *e. g. Vorticella, Carchesium, Zoothamnium, Scyphidia, Trichodina,* some species of *Epistylis,* &c., it describes scarcely more than one circuit round the disc, whilst in *Opercularia articulata* and *Epistylis flavicans* it runs round the disc three times; in other species intermediate lengths occur. The ciliary wreath, moreover, consists of a double row of cilia: those of the outer one are usually somewhat shorter than those of the inner, and though inserted upon the margin nearly in the same line as the others, yet they are set at a different angle, and apparently far more strongly bent outwards. In the vestibulum and œsophagus the cilia appear to stand in a single row. The peristom usually bears no cilia. There is no sufficient proof of the existence of muscles of the same type as those of the higher classes of animals. The contractile vesicle is single and circular; the nucleus sometimes oval, but often elongated and band-like. Besides fission and gemmation, true propagation by living germs or embryos, developed in the course of more or less complete transformations, affords an additional means of perpetuating and extending the several species.

The genera are distributed as follows:—

Body without stalk	Tail absent	Body covered with cilia		Stentor.
		Body smooth, cilia anterior		Trichodina.
	Tail present			Urocentrum.
Body stalked—often branched like a tree	Form of stalked bodies similar	Stalk flexible, deflection spiral	Simple	Vorticella.
			Branched	Carchesium.
		Stalk inflexible		Epistylis.
	Bodies of different form	Stalk inflexible		Opercularia.
		Stalk flexible, deflection spiral		Zoothamnium.

Of the several genera named and distinguished by Ehrenberg, two only are accepted by Dujardin, viz. *Epistylis,* with a rigid pedicle, and *Vorticella,* with a contractile stalk, simple or branched. He places *Carchesium* with the latter, maintaining that a generic character is not to be found in the simple or branched condition of the stalk alone, when the bodies are similar. Moreover, he failed to meet with animalcules having the characters assigned to the genera *Opercularia* and *Zoothamnium* by Ehrenberg. A third genus, under the name of *Scyphidia,* is established by him for the sessile species; whilst a fourth, *Vaginicola,* comprises all those species invested with a membranous sheath, and corresponds, in its constituent species, to the family Ophrydina (Ehr.) after the exclusion of *Ophrydium.*

Perty makes a different distribution of the Vorticellina to that proposed by Ehrenberg. Like Dujardin, he rejects the genera *Stentor* and *Urocentrum,* and transfers them to a family Urceolarina. On the other hand, he adds *Scyphidia* of Dujardin to the true Vorticellina, and makes no mention of *Carchesium.* Lachmann is another writer who rejects *Urocentrum* from the Vorticellina. Stein points out various defects in Ehrenberg's grouping of Vorticellina; and whilst he would, on the one hand, detach from it *Stentor, Trichodina,* and *Urocentrum,* he would, on the other, associate with it the several sheathed genera which form the family Ophrydina, viz. *Ophrydium, Vaginicola, Tintinnus,* and *Cothurnia.* Apart from these changes in the distribution of admitted genera, he adds two new ones, *Lagenophrys* and *Spirochona,* remarking of the former, that, in its free condition, it constitutes a transitional form between the radiated type of Vorticellina and the bilateral one of Oxytrichina and Euplotina. Lastly, Lachmann states that *Trichodina* and *Urocentrum* are not Vorticellina, and makes *Stentor* the representative of a new family, which he calls Stentorinæ. In this proposed new family he includes besides *Stentor*, a new genus (*Chætospira*), *Spirostomum*, and a fourth genus which he has merely referred to without naming or describing it. In the above plans of classification there is this in common, that the genera *Stentor*, *Trichodina*, and *Urocentrum* are excluded from among the Vorticellina, an exclusion warranted by their difference of organization and general characters. At the same time we are of opinion that the association of the Ophrydina with the Vorticellina is not correct in a systematic point of view, the existence of external sheaths being a well-marked and sufficiently distinctive character, although the homology in organization is otherwise, in every essential point, very close and striking. Probably *Trichodina* and *Urocentrum* should constitute an allied family or a sub-family of Vorticellina; *Stentor* the type of a second family; whilst the remainder of Ehrenberg's group, viz. *Vorticella*, *Carchesium*, *Epistylis*, *Opercularia*, and *Zoothamnium*, might be called the true Vorticellina. The new genus *Spirochona*, again, stands apart by so many peculiarities that it cannot be included within either of the groups proposed, and must be regarded as the (at present) solitary type of a new family, having the internal organization of Vorticellina, but destitute of their peculiar ciliated head. In framing his generic and specific distinctions, Ehrenberg made use of characters of no real value,—such, for instance, as the occurrence of similar and dissimilar bodies (zooids) on branching stems otherwise alike, the height of the stem, the thickness of its branches, and the dimensions of the attached animalcules.

The family Urceolarina (Duj.) is thus characterized:—"Animals variable in form, changing from a trumpet- or a hemispherical to a globular form; ciliated throughout, with a fringe of much stronger cilia along the upper and anterior margin of the body, continued as a spiral coil into the oral cavity, which is on the same border. They present the ordinary swimming movement, and can for a short time arrest their progress by fixing themselves by their posterior extremity to external objects." "This family," observes Dujardin, "connects the Vorticellina with the Bursarina, and includes the genera *Stentor*, *Urceolaria* (*Trichodina*, Ehr.), *Ophrydium*, and *Urocentrum*." The last-named genus is treated as very doubtful. As already seen, Perty adopts this family Urceolarina, but modifies it by rejecting *Ophrydium*, and adding *Spirostomum*.

Genus STENTOR (XXVIII. 16, 17; XXIX. 8).—Animal without pedicle, free, or attached by the posterior extremity of the body, which is conical, although it admits of very considerable modifications of form; it is entirely covered with cilia; a wreath of larger ones surmounts the head. Ehrenberg considered the longitudinal striæ along the body, and the circular ones at the anterior part, muscular fibres. The anterior ciliary wreath is coiled in a spiral manner about the head; in some species a row of longer cilia extends from the mouth, in a fringe-like manner, to the middle of the body. The Stentors increase by self-division, which is either longitudinal or oblique. The nucleus is band-like, moniliform, or round. The contractile vesicle is large, round, and placed on a level with the ciliary wreath, close to the œsophagus; it gives off, above, an annular branch, which surrounds the head of the animalcule just beneath the fringe of cilia, and below, a straight branch extending to the posterior extremity of the animalcule (XXIX. 7). The anus may often be perceived for a considerable time both before and after the discharge of matters. It is situated on the back, close beneath the ciliary circle. The Stentors are among the largest of the Infusoria, and all the species are visible to the unassisted sight. They are best examined between the plates of a large live-box, a portion of the decayed stem or leaf on which they are found being put in with them.

"It is," says M. Dujardin, "in the Stentors where we can view the several supposed internal organs isolately, that new observations will make known their real nature."

They are exclusively found in fresh standing water, or between plants where the water is still. Some of them are colourless, others green, black, or clear blue.

This genus gives name to the family Stentorina proposed by Lachmann and others, and, in the classification of Dujardin and Perty, is a member of the family Urceolarina (p. 581).

STENTOR *Mülleri* (XXVIII. 16, 17).—This is the "white funnel-like polpye" discovered by Trembley; it is large, the crown or wreath of cilia interrupted, and the lateral crest or fringe indistinct; when outstretched it is trumpet-shaped, but in its contracted state is ovoid; and during division, or when the water around it evaporates, a muco-gelatinous mass is thrown out as an external covering. When several are swimming in a glass vessel, they will gradually congregate, and select some particular spot, and then attach themselves, evincing, as Ehrenberg imagined, not only a degree of sociality, but of mental activity. These animalcules receive coloured food very readily; nucleus moniliform. Upon Lemnæ and other water-plants, even under ice. Size, stretched out, 1-20″; contracted, 1-120″.

Ehrenberg referred to the exudation of a mucilaginous coat as the prelude to the death of the Stentor; but, as Cohn has shown (*Zeitschr.* Band iii. p. 263), it takes place in perfectly healthy and lively animals, and is an instance of the widely-pervading process of encysting. This observer, indeed, tells us that, when the conditions of existence become unfavourable, animalcules previously attached by their tapering posterior extremity, as by a sucker resembling that of a leech, free themselves from their capsular envelope and swim away, displaying then a brush of cilia at the end of the tail. The notion of a sentiment of sociality and of mental activity, surmised by the Berlin microscopist, demands the exercise of a powerful imagination to realize it. Dr. Wright most kindly notices, in a letter to us, that *Stentor Mülleri* always secretes a gelatinous case into which it can retract. As the zooids divide they form a gelatinous mass, which is attached to weeds and often to the surface of the water, from which 10 or 15 Stentors aggregated together may sometimes be seen hanging with their *heads* downwards. The external gelatinous sheath in *Stentor* and other Vorticellina and Ophrydina, Dr. Wright proposes to call the "colletoderm," as the homologue of the gelatinous matter covering the polypidoms of the Hydroidæ.

S. *Rœselii* (x. 233, 234).—In form, size, and crest, this species resembles the preceding, but is of a more distinct yellowish-white colour. The nucleus is long, ribbon-shaped, and not moniliform; the contractile vesicle (seen at *) circular. Common in summer; upon decaying plants, &c., in standing water. 1-140″; extended, 1-24″

The moniliform intestine represented by Ehrenberg was very probably the chain of vesicular dilatations of the presumed vascular system connected with the contractile vesicle, and which is largely developed in the Stentors, on one side of the body, as a canal extending from a circular sinus around the head. Dujardin regarded this species as simply a variety of *S. Mülleri*; and there is no appreciable character truly distinctive between them.

S. *cæruleus* (XXIX. 8) resembles, exteriorly, the two preceding species; but its granules are blue, nucleus articulated and chain-like (moniliform). It is trumpet-shaped when extended, ovoid when contracted; white or semi-transparent, except when coloured by food. The lateral crest and frontal wreath are continuous. When kept in glass vessels, they often fix themselves to the sides in clusters. They are best examined when placed in a large live-box; a magnifying power of 100 diameters is sufficient. Amongst Vaucheriæ. 1-480″.

Except its much smaller size, there

seems nothing to sufficiently distinguish it from the preceding species; for the bluish hue of the granules cannot be admitted as a characteristic. Even the difference in dimension is no satisfactory indication of a distinct species; for the smaller animalcule may be but a younger specimen of the larger.

S. *polymorphus* (XXIX. 7) resembles the preceding in form. Granules of a beautiful green colour; nucleus articulated and chain-like; lateral crest indistinct; frontal wreath of cilia interrupted. This species will not receive indigo readily. Transverse self-division observed. Upon stones, decayed sticks, and leaves, in standing water. 1-120″ to 1-24″.

Lachmann (*A. N. H.* 1857, xix. p. 225) seems to intimate that this species is equivalent to *S. Mülleri* and *S. Rœselii.* Both in this species and in *S. cæruleus* Eckhard has described reproduction by internal germs or embryos. Between the cilia, disposed in spiral series, single long hairs, similar to those of many Turbellaria, are found, according to the testimony of Lachmann.

S. *igneus*.—Less than the preceding; granules yellowish-green; surface bright yellow or vermilion; nucleus spherical; lateral crest absent; frontal wreath of cilia interrupted. Found by Ehrenberg upon the water-violet (*Hottonia palustris*). 1-72″.

S. *niger* (*Vorticella nigra*, M.).—Small, of a dark brownish-yellow or blackish colour; granules olive-coloured; nucleus spherical; lateral crest absent; frontal wreath of cilia continuous. This species is often so abundant that it colours large pools, in turfy hollows, of a dark blackish hue, resembling an infusion of coffee. The swimming movement of this species is readily seen (as in the others) with the naked eye. 1-96″.

S. *castaneus* (Wright). — A species named in a letter to us by Dr. Wright, of which the only particulars given are that it is of a dark chestnut colour, and that it selects the tops of the stems of Myriophyllum as its home, and glues all the young leaflets together with a ball of jelly, within which a crowd of zooids is imbedded.

Genus TRICHODINA.—Vorticellina destitute both of tail and pedicle, distinguished from the preceding genus by the general surface of the body being destitute of cilia. They possess a vibrating wreath of cilia anteriorly, on one side of which is a simple, not spiral oral opening. They are mostly disc-shaped or conical. *T. Pediculus* has the posterior end abruptly truncated like the front, and also surrounded with a wreath of curved setæ, which it employs when crawling, in the manner of feet. In *T. tentaculata* there is a kind of proboscis. Coloured food is received by *T. Pediculus* and *T. Grandinella.* A kidney-shaped nucleus is seen in *T. Pediculus.* Many species live parasitic on freshwater Mollusca, or Zoophytes; but others have been found free in sea-water.

This description by Ehrenberg conveys a very imperfect conception of the real structure and appearance of *Trichodina.* The following account and figures from Stein will, however, supply its deficiencies:—"The genus *Trichodina* consists of naked and highly contractile animalcules, subject to very considerable variations of form in the direction of the long axis. Their usual figure is that of a truncated cone, much and suddenly distended posteriorly, and surmounted at their wider extremity by a wreath of cilia, which corresponds with the posterior ciliary wreath in other Vorticellina. The other, abruptly truncate extremity is furnished with an apparatus of hooks (XXIX. 15), whereby the animal can attach itself to other bodies. The mouth is circular, and placed on one side of the body, at a greater or less distance from the anterior extremity; it is furnished with a special zone of cilia to aid in the introduction of the alimentary particles." (It is, however, not circular, but a spiral fringe of cilia, as Dujardin stated.) The genus *Trichodina* (Ehr.) agrees in the main with *Urceolaria* (Duj.).

Of the several species enumerated by Ehrenberg, Stein asserts that two only are admissible, that the other three are foreign to the genus, and very incompletely observed beings. Thus *T. Grandinella* and *T. vorax* appear to be merely the embryos, or otherwise the gemmæ, of Vorticellina, whilst *T. tentaculata* is imperfectly known, and will probably always remain a questionable organism. Further, this author would unite *Trichodina* with *Urocentrum* into a subfamily of Vorticellina.

Lachmann (*A. N. H.* 1857, xix. p. 119) agrees with Stein in limiting the genus to the two species *T. Pediculus* and *T. Mitra,* and in rejecting the rest as not Vorticellina at all. According to him, *Trichodina Grandinella* and *T. vorax* are rightly referable to *Halteria* (Duj.).

Trichodina *tentaculata* (x. 227). — Discoid, destitute of the wreath of cilia, but with a fasciculus of vibratile cilia, and a styliform proboscis. 1-280″.

T. *Pediculus* (*Cyclidium Pediculus,* M.) = *Urceolaria stellina* (Duj.) (x. 228–230; xxix. 14, 15, 17).—Depressed, urceolate, and discoid, with a wreath of vibratile cilia anteriorly, and another of short moveable uncinate cilia, or hooked setæ, posteriorly. Ehrenberg remarks, "I have fed this species many times with indigo, and have seen numerous stomachs filled with the blue matter. It always runs upon the back, where there is a wreath of 24 to 28 mobile hooks (or uncinate cilia), and has the mouth and vibrating wreath of 48 to 64 cilia directed upwards." It appears to feed upon the little granules of the body of the Freshwater Polype (*Hydra,* 'Microscopic Cabinet,' pl. vii.) (Figs. 228 and 229 are side views, attached to a portion of a polype; fig. 230 is a top view). 1-570″ to 1-280″.

T. *Pediculus* (xxix. 14–17) is described in much detail by Stein (*Infusionsthiere,* p. 175). "It has," he writes, "a turban-shaped body; the truncated conical anterior segment is morphological with the rotary organ of typical Vorticellina, and is shorter than the very ventricose and expanded posterior segment, from which it is separated by a deep annular constriction or furrow, occupied by a wreath of vibratile cilia of less length than those forming the posterior zone. The oral aperture is seated in this furrow, the cilia of which are active in impelling food into the mouth. The posterior ciliary zone is parallel with the one in front, just described, and occupies the posterior surface of the hindmost segment of the body, near to the line of attachment of the circlet of uncini, as can be best seen when the animal is dead. It is this zone which principally serves for locomotion. The anterior segment can be retracted, and even vanish, by being taken up into the posterior, when the figure becomes cylindrical, with abruptly truncate ends. The posterior segment also contracts itself considerably, and in so doing presents several annular folds. The margin of the truncated extremity, which is much smaller than a section made through the middle of the posterior segment, is fringed by a firm cartilaginous or horny ring, having both on its outer and inner face a series of uncini, placed at equal distances from each other, and somewhat constricted behind the origin of each pair. The inner row of uncini lie in the same plane as the posterior surface; but the external row are strongly turned outwards and backwards. Besides these is a structure not hitherto described, consisting of an annular, transparent, elevated rim or collar, often of a slight yellow colour, and of a horny aspect, placed around the outer margin of the corneous ring, above the base of the outer series of uncini. It is extremely flexible, directed obliquely outwards, and marked by very fine lines. The circlet of hooks is at once dissolved by acetic acid, whilst this structure remains; and, on the other hand, the whole prehensile apparatus disappears when the animal is put into alcohol." The structure of *Trichodina,* as now unfolded by Stein, was both imperfectly and erroneously conceived by Ehrenberg.

The long diameter of the largest *Trichodina Pediculus* Stein met with was 1-360″; the transverse diameter was about the same. Small specimens occurred of only half the size, but complete in all the details of organization.

T. *vorax.* — Oblong, cylindrical, or slightly conical; anterior part convex, and crowned with cilia; the back rather attenuated and smooth. 1-570″.

This and the next species are, from their dissimilarity to *T. Pediculus,* removed by Dujardin to another genus he names *Halteria,*—the two being equivalent to *Halteria Grandinella,* which again, in Stein's opinion, is the embryo of an Acinetiform phase of a *Vorticella.*

T. *Grandinella* (M.).—Nearly spherical; sharply attenuated posteriorly; a wreath of cilia surrounds the truncated fore part.

This species is liable to be mistaken, by an inexperienced observer, for a free *Vorticella*; its true distinguishing character appears to be its open wreath of cilia. 1-1500" to 1-860".

T. *Mitra* (Siebold) (xxix. 16).—Anterior segment elongated, cylindrical, much longer than the slightly wider and more discoid posterior segment, into which it gradually expands. The outermost margin of the posterior segment has a similar wreath of cilia to that of *T. Pediculus*; but the prehensile apparatus differs in the two species. In *T. Mitra* the undulating cartilaginous ring is not armed with hooks, but has only the annular membrane, precisely like that in the other species, except that it is relatively smaller, less distinctly striped, more colourless and transparent, and therefore more readily overlooked. Between the two segments is the deep furrow in which the mouth is placed, from which a row of cilia extends towards each end at right angles to the posterior ciliary zone, and is homologous with the anterior wreath of cilia of *T. Pediculus*.

Genus UROCENTRUM (X. 231, 232).—Free, with a tail-like style, but no pedicle, and no cilia, except a wreath anteriorly; oral aperture simple. Self-division transverse. Ehrenberg thinks the eyes, which Müller supposed he had seen, were most probably the traces of cilia, which he appears to have overlooked.

UROCENTRUM *Turbo* (*Cercaria Turbo*, M.) (x. 231, 232).—Hyaline, ovate, trilateral, with a style, or setaceous tail, one-third of its length. Ehrenberg says, "The little tail is not a separable *Vorticella*-stalk, but an articulated style on the back—perhaps a foot." With Lemnæ and Confervæ. Fig. 232 a dorsal, 231 a side view. 1-430" to 1-280".

Genus VORTICELLA (XXVII. 1–5).—Crowned with cilia anteriorly; stalked when young, but at a later period, and also after self-division, sessile. The shape of the zooids, when stalked, is similar; the pedicle can be suddenly deflected spirally, by means of the long muscle within it, but it is never branched. At certain periods a second wreath of cilia is produced at the posterior part of the body. Not only, according to Ehrenberg, can numerous stomach-cells be seen, but likewise the gradual passage of the food onwards, in a twining sort of intestinal canal, though this is not easily observed, on account of the periodical deflection of the pedicle. However, in the genera *Epistylis* and *Opercularia*, whose pedicles are comparatively motionless, the nutritive apparatus may be much more perfectly investigated. The mouth and discharging orifice are separate, but lie in the same hollow, at the anterior margin. The granules are variously coloured, and constitute, in Ehrenberg's language, clusters of ova; nucleus elongated, contractile bladder round. The animalcules are androgynous. The supposed increase by the growth of young animalcules out of the pedicle (or of gemmæ), like flowers on the stem of a plant, has arisen from erroneous observation. When the animalcule loosens itself from its pedicle or stalk—a circumstance which, says Ehrenberg, "takes place at certain periods—the stalks die, or disappear, just like the shells of crabs, or as the nails and hair." The muscular fibre within the stem requires stops, or an achromatic condenser, under the stage, to render it distinct.

The *Vorticellæ* being of so considerable a size, and easily procurable, have formed the subject of numerous investigations into their organization; but yet no observers have been able to coincide entirely with the views of Ehrenberg. Among the most recent researches are those of Prof. Stein, which have been fully put forward in the general history of these animals, to which we must refer (see p. 277 *et seq.*). Suffice it to say that the winding intestinal canal, the distinct stomach-cells, the clusters of ova, the androgynous nature mentioned in the above account from Ehrenberg of the internal organization of *Vorticellæ*, have, not only in Stein's opinion, but in that of nearly every other naturalist, no existence; the appearances so interpreted are explicable in a different manner. Adopting the results of recent discoveries, the following descriptive characters may be laid down.

Body bell-shaped (campanulate), supported on a highly contractile, unbranched pedicle or stem, and surmounted at its wide upper extremity by a dilated and somewhat everted margin, or "peristom." The wide anterior extremity is closed by a "disc," fringed with cilia, which commence on one side of a depression or fossa in the peristom, called the vestibulum, whence they ascend to surround the disc, and after continuing down its sides or "stem," enter the mouth, and thence return to their starting point, thereby completing a spiral ciliary wreath, or rotary apparatus, which serves by its vibrations to draw food inwards to the mouth, and, when the animal detaches itself, as an organ of locomotion. The disc may be slightly elevated above the peristom, but less so than in other true Vorticellina; when so elevated, the ciliary apparatus is said to be expanded. On the other hand, it may be withdrawn under cover of the peristom, the cilia disappearing from view; and when more strongly contracted, the whole disc is so drawn within the body that the entire appearance of the anterior extremity or head of the animal is lost, its ciliary mechanism being so inverted that it appears internally like an irregular sigmoid cavity, in which the cilia may possibly be distinguishable, whilst the peristom is itself completely closed in upon the whole. In this state of complete contraction the *Vorticella* resembles a shut ovoid sac. Except the head, the rest of a *Vorticella* is destitute of cilia. The fossa lying between the sides of the ciliary disc and the peristom is the vestibulum, into which both the oral and anal outlets open, within a very short space of one another. The mouth opens below into a ciliated pharynx or œsophagus, which is extended a considerable distance into the interior as a digestive tube, terminating, it would appear, suddenly by an open end. The food received at the mouth is transmitted through the œsophagus, and is formed at its extremity, with the aid of water, into a globule or vacuole, which is pushed onwards by the *vis à tergo* in a circular course towards the anal outlet. Besides molecules and granules derived from food (vesicular bodies composed of oily or other matters), there are always present in the interior a round contractile vesicle and an elongated curved band-like nucleus, often with several minute clear spaces or nucleoli. The vesicle is usually placed near the lower end of the digestive tube, and the curved, horseshoe-shaped nucleus lies across at the posterior third of the animalcule. The *Vorticellæ* multiply by longitudinal self-division, and by the growth of gemmæ from their base, and propagate by the resolution of the nucleus, after encysting itself, into numerous *Euglena*-like or Monadiform beings, and, according to Stein, by ciliated embryos through the medium of a previous conversion into *Acinetæ*. The new beings formed from fission or gemmation are at first in a contracted condition, and on their detachment are found to be furnished with a posterior circlet of cilia to serve as a means of locomotion until they affix themselves and proceed to develope a pedicle, after which it disappears, and the ordinary ciliary wreath of the head unfolds itself. Indeed, even when these processes of multiplication are not in operation, a *Vorticella* can detach itself and leave its stalk, or swim away with its pedicle when loosened from its hold.

The pedicle is remarkably contractile, drawing itself into a close coil with extraordinary rapidity, and again uncoiling itself with equal quickness, regulating these movements by external conditions, as though possessing consciousness and will. The pedicle is a hollow tube, containing a thread or band within it, to which its contractile power is due.

VORTICELLA *nebulifera* (*V. nebulifera* et *V. Convallaria*, M.).—Body campanulate; its base, to which the pedicle is affixed, may be either conical or hemispherical, according to its state of expansion or contraction; the pedicle or stalk is about five times the length of the body, and can form as many as ten coils. These creatures usually congregate together,—though each is independent of its neighbour; for on the approach of any foreign body to one, it withdraws, by coiling up its pedicle, while the others remain stretched out in search of food. An amplification of 300 diameters is necessary to exhibit the cilia. During longitudinal self-division the body becomes broader: gemmation takes place from one or other side, close to the insertion of the pedicle. Abundant, appearing like a white film, on the stalks and roots of Lemnæ and other water-plants, even in winter under ice. 1-570″ to 1-280″.

This is one of the species of *Vorticella* in which Stein believed he proved the development of an *Acineta* from the encysted animal, and also, under other circumstances, the generation of a brood of young Monadiform beings or germs.

V. *citrina* (M.).—More hemispherical than the preceding, and the frontal margin more expanded. Upon Lemnæ, rarely with the former species. 1-430″ to 1-210″; stalk 3 to 4 times that length.

Perty speaks of this species as having a stiff stem, and apparently closely related to the genus *Stentor*. Dujardin adopts this specific name for a *Vorticella* defined as being very variable in form, often campanulate, rarely conical, having a wide projecting border, variously contorted or irregular.

V. *microstoma* (XXVII. 1–6).—Whitish grey, ovate, narrower at the ends; frontal margin not expanded or campanulate; during contraction the animal is annulated; multiplies by longitudinal and transverse (?) self-division, and by gemmation. In stagnant water. 1-2300″ to 1-240″; stalk six times longer than the body.

This species was the subject of the minutest investigations by Stein, who not only represented it as becoming encysted, but also as being either transformed into an *Acineta* or *Actinophrys*, from which a ciliated embryo is developed, or as giving origin, without such a metamorphosis, to a multitude of germs. He remarks on the immense range of size seen among different examples of this animalcule, viz. from 1-300″ to 1-3600″ (XXVII. 5), the smallest equally with the largest exhibiting the same structure. The figure he describes as pear-shaped, the anterior half contracted; the ciliated disc slightly everted, not campanulate; rotary organ small, and elevated but slightly above the peristom. He objects to Dujardin's union of this species with *V. convallaria*, under the name of *V. infusionum*, as erroneous, the two being perfectly distinct beings.

V. *Campanula* (*Vorticella lunaris*, M.) (XXIX. 1).—Hemispherical, not annulated, bell-shaped, with the frontal margin broad, truncated, and not expanded. Colour whitish-brown. This species appears like a thick bluish film upon water-plants, and the single animalcules are discoverable with the naked eye. 1-120″; stalk seven times longer than the body.

Perty adopts Müller's name *V. lunaris* for a species which he considers equivalent both to *V. Campanula* and *V. patellina*.

V. *hamata*.—Small, ovate, hyaline, attenuate at both ends; body obliquely attached to the pedicle. 1-570″.

V. *chlorostigma* (*Vorticella fasciculata*, M.).—Green, ovate, conical, campanulate, and annulated; frontal margin (peristom) expanded. Often covers grasses and rushes with a beautiful green layer. 1-240″; stalk five times the length of the body.

V. *patellina* (M.). — Hemispherical, campanulate; frontal portion very much dilated; its margin greatly expanded, and often turned backwards. 1-480″; stalk about seven times the length of the body.

V. *convallaria* (*V. crateriformis, citrina, gemella, globularia, hilaris, nasuta* et *truncatella*; *Enchelys Fritillus*; *Trichoda gyrinus*, M.).—Ovate, conical, campanulate, annulated; hyaline or whitish; frontal portion dilated, its margin slightly expanded. This appears to have been the first infusorial animalcule discovered. Leeuwenhoek, the discoverer, found it in stagnant rain-water, at Delft, in April 1675. It occurs in considerable abundance upon the surface of vegetable infusions, with *V. microstoma*, from which it is distinguished by its broad front, which gives to it a bell-shaped or campanulate appearance. Carus, in 1823, fancifully represented it as arising from spontaneous generation in oil, or from an accidental mixture of oil colour and spring-water. It has been described under various names by different naturalists. 1-430″ to 1-24″; stalk six times its length.

This well-known animalcule is usually found attached to extraneous bodies in water; such as the leaves of duck-weed, small aquatic shells, clusters of the ova, or the larvæ of insects; an example of the latter is shown in the *Microscopic Illustrations*, fig. 30, where it may be considered as a parasite, or rather an epiphyte. As, when fully developed, it is mostly attached to some stationary object, it affords many facilities to the microscopist for observation, and forms a good object also for ascertaining the defining power of his instrument, and his expertness in its management; for much of the clearness in structure will depend on the manner in which he manages the illumination. If this be not attended to, and the instrument has not sufficient power and penetration, it will exhibit only two cilia instead of a circular row; indeed this animalcule is described and drawn in this manner by the old authors,—an error which recent improvements in the microscope have demonstrated.

V. *picta*.—Ovate, conical, campanulate; frontal portion dilated, and its margin slightly expanded. The pedicle is very slender, and curiously marked throughout its length with red dots. 1-1150" to 1-570"; stalk four to five times as long.

Perty treats *V. lunaris*, *V. fasciculata*, and *V. cirrata* of Müller as distinct species, instead of accepting them as varieties of others named by Ehrenberg; but he fails to give the characteristics necessary to their establishment as such. It is to be remarked, however, that *V. lunaris* and *V. fasciculata* are, he is inclined to believe, merely varieties of the same species.

Vorticella Ampulla (Müller) is treated by Lachmann as the representative of a new genus, as yet unnamed, belonging to the Stentorinæ (*A. N. H.* 1857, xix. p. 128).

V. infusionum (Duj.) is not equivalent to *V. microstoma* and *V. Convallaria*, as he represented it to be. He describes it as commonly ovoid or nearly globular, truncated at the head, with a slightly projecting border. The pedicle is very flexible, its surface striated obliquely.

V. ramosissima (Duj.) = *Carchesium polypinum* (Ehr.).

V. Arbuscula (Duj.) = *Zoothamnium Arbuscula* (Ehr.).

V. lunaris (Duj.) = *V. Campanula* and *V. patellina* (Ehr.).

Genus CARCHESIUM (XXX. 9).—Distinguished from the preceding genus by the spirally flexible branched pedicle. The bodies (zooids) upon the pedicle are all of the same form. The organization of this genus is not so well known as that of *Vorticella* and *Epistylis*. There is a simple wreath of cilia, which during quick vibration appears double; and, as in *Vorticella*, a posterior circlet is produced at certain periods; within the pedicle a transversely folded contractile band is observed during contraction. The mouth is lateral. Internally are whitish granules, and a contractile bladder; but the nucleus is indistinct. The growth of gemmæ has been observed; and the zooids can detach themselves from the stalk, as in the case of *Vorticella*.

One of the best distinctive features between *Carchesium* and *Zoothamnium*, is that the contractile band of the former is not continuous throughout the pedicle and its branches as it is in the latter (see p. 293). This is noticed both by Stein and Dr. Wright: the latter adds, "The division of the zooids is more complete in *Carchesium* than in *Zoothamnium*. In the former, at each division, one of the zooids produces a new muscle not connected with that of the zooid from which it has separated."

CARCHESIUM *polypinum* (Leeuwenhoek) (*V. polypina*, M. and Duj.) (XXX. 9).—Conical, campanulate, white; the frontal portion broad, truncate, and its margin expanded; pedicle branched in a sub-umbellate manner. The axis matter or supposed muscle of the pedicle, first observed by Mr. Varley, is very distinct. 1-570" to 1-430".

C. *pygmæum* (*Zoothamnium Parasita*, Stein).—Very small, ovate, white, rather dilated in front; pedicle branched in a bifid, rarely in a trifid manner. 1-2400". Berlin. On *Cyclops quadricornis*.

C. *spectabile*.—Conical, campanulate, dilated in front; branching in an oblique conical polypary, attaining two lines in height. Berlin.

Genus EPISTYLIS (XXVII. 16, 22, 23; XXX. 11).—Pedicle rigid, either simple or branched; all the zooids of the same figure; or, in other words, they are *Vorticellæ* or *Carchesia* with a rigid hollow pedicle, without an internal contractile band. The situation of the mouth and anal opening is easily demonstrated by the employment of coloured food. In *E. plicatilis*, says Ehrenberg, the whole course of the alimentary canal can be seen. A contractile sac and a short band-like nucleus are observable in many; the latter, however, is spherical in *E. nutans*. Longitudinal self-division and gemmation frequently seen. The *Epistylides* are among the largest of the Vorticellina, and are exclusively found in pure water, on aquatic plants or animals.

Stein's researches throw additional light on the structure of *Epistylis*, which, he says, resembles generally that of *Vorticella*. The body has usually an ovoid or almost spindle-shaped figure, truncate in front, where a slightly everted ciliated peristom, of a sphincter- or lip-like character surrounds it, and gives to the whole being somewhat of a bell-shape. Within the peristom is a ciliary disc capable of being protruded or retracted at the pleasure of the animal, and having on one side the oral aperture. This disc is the "rotary organ" in Stein's description, and in *Epistylis* its pedicle or stem is always short and thick. When retracted, the sphincter-like peristom closes over the rotary organ like a lid, and then the whole animal acquires a pear-shaped or globular figure. When the contraction has proceeded to its utmost, the peristom appears like a wedge-shaped or cylindrical process surmounting the body. The mouth opens into a slightly coiled, tapering tube, which ends abruptly towards the centre of the body; near its termination is a contractile vesicle, and not far from the last an elongated band-like or reniform nucleus. *Epistylis* multiplies in precisely the same manner as *Vorticella*, by fission and gemmation. Stein believes he has traced a cycle of changes through which it passes, between the encysted condition on the one hand, and the development of a ciliated *Trichodina*-like embryo from an Acinetiform phase of existence on the other. His observations tend to show that the embryonic being developed from the *Acineta* of *Epistylis anastatica* is similar to *Trichodina Grandinella* (Ehr.), and probably identical with it. In *E. nutans* he satisfied himself of the occurrence of similar transformations, but felt less assured of their occurrence in *E. grandis, E. berberiformis, E. Barba*, and *E. plicatilis*.

The stem or pedicle is inflexible. No canal, as represented by Ehrenberg, is usually discoverable; but sometimes the stem is finely striated longitudinally, and in older specimens has at varying distances transverse lines or false joints. Dujardin proposed to amalgamate the two genera *Epistylis* and *Opercularia*, since he could distinguish no generic differences between them. In this proposal, however, he was wrong, for, as Stein shows, there are sufficient distinctive peculiarities to warrant their generic independence. (See description of OPERCULARIA.) The animals seated on its branches, by their mode of articulation, enjoy considerable latitude of motion, and are also able in some degree to shorten themselves by the annular segments of their base.

The stem is secreted by the animalcules it supports. When fission has taken place, two beings are for a time seen seated at the extremity of the same pedicle; but soon each begins to produce from its attached base a new pedicle for itself, and thus the original stem becomes branched, and this in a furcate or dichotomous manner.

All the members of the same little tree (polypidom) are of nearly equal size. In the case of *E. nutans*, the largest noticed were 1-20th of a line in length; whilst in other polypidoms, whose stems and branches were proportionately thinner, examples were met with of very minute size (XXVII. 22, 23). In the smallest, no anterior cilia and no contained globules were visible; in larger ones, though only 1-150th of a line in length (XXVII. 23), such were found. These latter forms constitute *Epistylis Botrytis* (Ehr.).

EPISTYLIS *Galea.* — Large, conical, contractile by transverse folds; mouth lateral and projecting; pedicle thick, branched, and articulated. Upon *Ceratophyllum.* 1-120".

E. *anastatica* (*V. anastatica, cratægaria* et *ringens,* M.).—Oval, without folds; frontal margin dilated and projecting; pedicle dichotomous, smooth—or squamous with foreign particles. The granules are white by reflected, and yellowish by transmitted light; the clear vesicle is often to be seen, but not its contraction; growth of gemmæ unknown; self-division longitudinal. Upon *Ceratophyllum* and small aquatic Mollusca and Entomostraca. 1-280"; height of little tree 1-140".

"*E. anastatica,*" says Stein, "differs from *E. Digitalis,* which it very closely resembles, by the form of its body, which is always funnel-shaped and campanulate, like that of *E. plicatilis,* only less elongated, and by the branches of its stem being outspread in a fan-like manner and acquiring a nearly equal height, or an umbellate condition." He adds, "The three species most nearly allied, viz. *E. anastatica, E. plicatilis,* and *E. Digitalis,* have, when studied at different ages, few points of separation, except that furnished by their habitats,—*E. plicatilis* living upon the shells of Mollusca; *E. anastatica* upon the roots of *Lemna*; and *E. Digitalis* upon *Cyclops quadricornis.*"

E. *plicatilis* (*V. annularis et pyraria,* M.).—Conical and elongated, contractile in annular folds; frontal margin dilated, truncated, and slightly projecting; pedicle dichotomous, often corymbose, smooth, or, when foreign bodies adhere, of a scaly appearance. This species is white to the naked eye, but somewhat yellow beneath the microscope; it is very much like the preceding, is often found with it, but is distinguished by being larger, by its ring-like folds when contracted, and by the tasselled or tufted appearance of the cluster. 1-280" to 1-210".

The stem, says Stein, is solid and longitudinally striped. The nucleus is reniform, and the contractile vesicle lies within the substance of the large rotary organ. In old stems transverse lines or joints appear, at a distance from one another. The largest examples Stein met with were 1-168" in length.

E. *grandis.* — Broadly campanulate, stalk decumbent, slender, smooth; the branches flexible and without articulations, but much tufted. This is not only the largest freshwater species of *Epistylis,* but it also forms the greatest masses. Its proper colour is a bluish white; but it often appears of a yellow or greenish hue, from the colour of its food. Upon *Ceratophyllum* and *Nymphæa,* often like a bluish-white slime, easily broken up. In masses several feet long, and two to three inches thick. 1-140" to 1-120".

E. *flavicans* (*V. acinosa et bellis,* M.). — Large, broadly campanulate, and of a yellow colour; pedicle smooth, its branches coarctate. The branches are dilated at the axillæ. In this species the alimentary canal is very evident. Size (stretched out) 1-190"; tree 1-9" high.

Although Stein represents the stem in *Epistylis* to be, as a rule, solid, yet, in a passing notice (p. 72) of *E. flavicans,* he remarks that the pedicle evidently had a hollow central canal.

E. *leucoa* (*Volvox Sphærula,* M.). — Large, broadly campanulate; pedicle erect, smooth, and articulated; the branches capitate or collected in a head. These animalcules are convex anteriorly, have distinct colourless granules, a simple wreath of cilia, and a round mouth on the margin. The nucleus is bent in the form of the letter S. 1-120"; tree 1-24".

E. *Digitalis* (*V. Digitalis, ringens* et *inclinans,* M.).—Small, cylindrical, campanulate; stem dichotomous, and finely annulated. This well-marked form infests the *Cyclops quadricornis,* which it sometimes completely covers. In the beautiful little tree this species forms by its branching, the *Notommata petromyzon* nestles just like a bird in a bush, and fastens its eggs to its branches. Coloured food is readily taken. 1-430"; tree 1-20".

The figure is more like that of the flower of the foxglove (*Digitalis*), as the name implies, than bell-shaped; for the peristom is very little everted, and its diameter not greater than the middle of the body. The rotary organ protrudes some distance, and lies very obliquely. The nucleus is band-like, and curved in a semicircle. The annulation of the stem could not be seen by Stein, except, as in very many *Epistylides,* near the junction or bifurcation of the branches, and occasionally in very old specimens: in these last it often has a rusty colour.

E. (?) *nutans* (*Opercularia nutans,* Stein). — Ovate, attenuated at both ends; mouth two-lipped and prominent. The pedicle annulated (XXVII. 16, 22, 23). "This animalcule," says Ehrenberg, "can push forth a bladder between its lips, like (si parva licet componere magnis) a camel can its palate". 1-430"; tree 1-24".

The process above alluded to by Ehrenberg as protruded from the head of this animal is undoubtedly the sort of under lip alluded to by Stein in his account of *Opercularia* (see next page). This author, again, confirms Ehrenberg in his doubt as to the position of this species, and shows that it is an *Opercularia*.

E. *Botrytis.*—Very small, ovate, crowned with cilia. They resemble grapes upon a simple hyaline pedicle. This species together with *E. Arabica* and *Carchesium pygmæum* are, in Stein's opinion, not really distinct species, but different phases of the same animalcule. 1-2400"; tree 1-240" (see p. 589, last line).

E. *vegetans* (*Volvox vegetans*, M.).—Very small, ovate, crowned with cilia (?); disposed in clusters, like the preceding, upon a branched pedicle, of a yellow colour. When the water containing this species is coloured with indigo, strong currents are seen at the front or head of each animalcule, evidently caused by a vibratile organ; but whether this is a wreath of cilia or a simple proboscis, is undetermined; if a proboscis, this creature would belong to the Monads, where it would form the type of a new genus. In river-water. 1-3450"; tree 1-140".

Brightwell says (*Fauna Infusoria of Norfolk*, 1848) that the armed or oval animalcules are furnished with a long filament, that, when the water is shallow, they detach themselves, and swim about with a revolving motion. The organ of motion he states to be a long filament (proboscis); if so, the animal is not an *Epistylis*. Stein treats it also as a very doubtful *Epistylis*.

E. *parasitica.*—Small, conical, campanulate, and solitary; pedicle simple and smooth. Upon *Zoobotryon pellucidus*. 1-570"; with pedicle 1-120" to 1-24".

E. *Arabica.*—Small, oval, campanulate; pedicle but little branched, smooth, and hyaline. In the Red Sea. Size of tree 1-140".

This species, as well as *E. Botrytis* and *Carchesium pygmæum*, are adduced by Stein as insufficiently marked, and referred by him to the young and incomplete forms of other species.

E. *Barba.*—Ovate, oblong, white; branches dichotomous; longitudinally and regularly striated. On larvæ of insects.

E. *berberiformis* = *Opercularia berberina* (Stein) (XXIX. 4).—Oblong, subcylindrical, white; stem dichotomous, articulated, and striated, its divisions dilated at their apices. Parasitic, Berlin.

This is not, as Stein shows, a species of *Epistylis*, but of *Opercularia*, under which we shall introduce it with the descriptive account this able writer supplies.

E. *euchlora.*—Oblong, rather expanded in front, with green ova; stem dichotomous. 1-13" in height, smooth. Parasitic on *Planorbis cornea*, Berlin.

E. *pavonina.*—Very large, helmet-shaped, elongated in front; stem very high, dichotomous, striated, and hence, by decomposing light, displays many hues. Often 1-3" in height. Berlin.

E. *crassicollis* (Stein) (XXX. 11).—Stem of considerable height, acutely and dichotomously branched so that the several zooids it supports are brought nearly on the same level (corymbose). Branches smooth, transparent, straight, and of equal thickness. In some specimens transverse lines or joints occur; and the stem is frequently dilated at the point of divergence of its branches. Animalcules ovate, contracted posteriorly, and also in a slighter degree anteriorly. The annulated, hoop-like peristom surmounts the body, having a rather smaller diameter. The rotary disc is convex, but rises only slightly above the peristom. The œsophagus and its intestine-like continuation curve backward almost to the posterior extremity of the body. The contractile space lies close to the lower end of the stem of the rotary organ; the nucleus is horseshoe-shaped. Contents white, frequently with specks of red. Largest specimens 1-240" in length, and 1-480" in width. Occurs on the bristles of the hind feet and of the jaws of Entomostraca.

E. *branchiophila* (Perty).—Spherical, with a truncate base; colour grey. Stem and branches colourless and smooth. 1-360"; length of polypidom 1-96". The animalcules are sparse in reference to the dimensions of the stem: the latter often rugose at its junction with the animal it supports. When the stem contracts it does so only on one side, and not completely across. Both this description and the figures given in illustration by Perty are, as Stein observes, insufficient to characterize the species. The latter writer retains the name, however, for an *Epistylis* having a relatively thick stem, of moderate height, repeatedly forked, finely striated and somewhat curved. Of the two branches resulting from a bifurcation, one attains a much greater length than the other; hence the appearance of a main stem and a subsidiary branch. The zooids terminating the ramifications are pear-shaped, the width nearly equalling the length, and almost globular when the peristom is contracted. They are of a greyish hue. The rounded, lip-like, ciliated peristom is of less diameter than the widest part of the body; and its entire space is occupied by the rotary organ, which is only a little elevated above it when extended. The nucleus is elongated and vermicular. The average length of the body is 1-360" to 1-280"; and the width 1-456" to 1-336". Gemmation may be frequently seen, the buds growing from the fore part of the body behind the peristom.

Genus OPERCULARIA (XXIX. 4; XXX. 1, 2, 27).—Branched pedicle, stiff and rigid, supporting dissimilar corpuscles (zooids). The anamalcules have two lips; the superior one, supported by a muscle, is somewhat like a lid (operculum), which is a characteristic. *Opercularia* = *Epistylis* with dissimilar corpuscles. The organs of locomotion consist of a wreath of cilia, and a long muscle within the body; this raises or depresses the frontal region, in the form of an upper lip. Food is taken into, and its effete portions discharged from the large vestibulum situated in front and rather to one side, and to and from which the alimentary canal is seen running. Self-division and the separation of the zooids from the stalk may be frequently observed. The large dissimilar bodies occur singly beneath the animalcules, more especially in the axillæ of the branches; some are very large and egg-shaped, with hairs at their point, and only a small, round, non-vibratile opening. Ehrenberg observes that such are most probably parasitic bodies. In all probability, however, they are encysted corpuscles.

The following characters, contrasted with those of *Epistylis*, are given by Stein. The peristom is, in *Opercularia*, merely a single border, neither ciliated, thickened, nor everted in a campanulate manner. The body, therefore, is elongated, ovoid, constantly narrowed anteriorly, and simply truncated. The opening of the peristom, which also forms that of the mouth, extends as a wide and deep cavity (the vestibulum) to the œsophagus, which is prolonged far into the body as a narrow digestive tube. A distinction between this last canal and the œsophagus is indicated by a group of three or four strong cilia placed at its commencement. The rotary organ springs from the wide oral cavity, on one side, by a narrow point, which is the apex of its trumpet-shaped figure. The base of this long conical sac is formed by its ciliated disc, which is thrust much above the peristom when extended, but can be drawn down upon it and close it: the whole organ is very moveable. The older observers looked upon the rotary organ as a valve or lid; and Ehrenberg supposed it to have a long retractile muscle which could close it upon the mouth. However, no muscle exists within the pedicle of the organ; for this is a hollow sac filled with the same substance as the general cavity of the body, and in direct communication with it. The pedicle of the ciliary disc is longer and more moveable than that of *Vorticella* and *Epistylis*. The genus *Opercularia* is further distinguished by the presence of a delicate membranous, transparent process which stands out from the throat like an internally fixed collar, and is elevated above the peristom, forming a sort of under lip to the rotary organ. Whether this is ciliated, or only a vibrating membrane, Stein remains in doubt. It is the same structure as is referred to by Ehrenberg in his note on *Epistylis*? (*Opercularia*) *nutans* as a protrusile bladder-like process (see p. 590).

OPERCULARIA *articulata* (*V. Opercularia*, M.) (xxx. 1) occurs as a little shrub, 1-6" to 1-4" high, white and dichotomous; carmine and indigo readily taken; and Ehrenberg states he saw as many as forty-four stomach-cells filled, resembling a girdle in the middle of the body. The stalk is very delicately striated in a longitudinal direction, and shows, at its ramifications, a transverse line, or joint. Upon *Dytiscus marginalis.* 1-430″.

Stein creates several additional species of *Opercularia,* and has entered into many details respecting the structure of *O. articulata* (xxx. 1, 2). According to him, the body is spindle-shaped or ovate-elongate, and truncate before and behind. The peristom, which is continuous with the body, forms a simple terminal edge, sometimes quite smooth, at others plaited longitudinally. Similar plaits often occur at its posterior half, when the animalcule contracts itself. The disc of the rotary organ has three circlets of cilia, is contractile and changeable in form. The oral cavity behind the margin of the peristom is very wide and deep, expanded as a capacious sac, from one corner of which, posteriorly, the digestive tube proceeds. It is lined internally by a delicate hyaline membrane, which projects beyond the peristom like an upright collar. At the base of the body is a dense collection of granules, apparently of a fatty character. The nucleus is horse-shoe-shaped, and a round contractile space lies near to the digestive tube at its commencement. There is a peculiar glandular-looking body on each side of the oral cavity at the anterior part of the body, the nature of which is not determined. When in a state of contraction the animal is thrown into annular folds, the rotary organ completely retracted, and the peristom closed over it in a sphincter-like manner, the whole body assuming a spindle-shaped form, or, when contracted to the utmost, a pyriform or orbicular figure. Reproduction takes place by gemmation; but fission has not been observed: Stein believes in the transformation of the animals into *Acinetæ,* and the development from these of ciliated germs (xxx. 3, 4).

The length of the body of the largest specimens, when extended, is 1-96″; and the greatest width, at the middle, 1-216″. The stem is very variously branched, and is less rigid and more flexible than in other species. The transverse lines or false joints are not characteristic, and the longitudinal striation is not always observable.

O. *berberina* (Stein) (xxix. 4) = *Epistylis berberiformis* (Ehr.).—Animalcules outstretched elongated, cylindrical, slightly contracted before and behind: about 2½ times longer than broad, without reckoning the extruded rotary organ. No separable peristom exists at the anterior truncated extremity (*i.e.* in technical phrase, it is obsolete); rotary organ comparatively shortly stalked, its disc having a single whorl of cilia. Oral cavity capacious, as in *O. articulata*; its membranous lining undulating, and seen with difficulty. An anal opening appears at the base of the oral cavity, not far from the orifice of the œsophagus. Even when expanded, the body is surrounded by thickly-placed annular folds, which become much more strongly pronounced when it contracts itself. The surface of the body is covered by a very firm, transparent, structureless membrane, which can be isolated for examination without any special preparation, and is often left behind after death as a distinct sheath or skeleton. Multiplication by gemmation has not been observed; but fission is common. The largest specimens were 1-190″ in length, and 1-570″ in width.

The form of the stem is very variable, for two similar specimens are scarcely to be found; yet in all, the animalcules are supported at different heights, on stems varying in length, and therefore not corymbose. The stem, likewise, has not the stiff, regular construction of most *Operculariæ* and *Epistylides,* but is generally curved outwards, and has at variable distances transverse lines or joints; the extremity supporting the animalcule is expanded. It is throughout solid, colourless, and diaphanous, and if at all striated longitudinally, is so in a very faint manner. On aquatic animals. Stein believes he has discovered its *Acineta* (xxiii. 17, 20).

O. *Lichtensteinii.*—Body stout, short, barrel-like, the length not being double the width; except in sparingly-branched stems, the opposite ends are little contracted. The rotary organ is but slightly elevated above the peristom; its stem is short, thick, and almost cylindrical, little exceeded in width by the disc surmounting it, which has but a single circlet of cilia. The membranous process within the oral cavity rises above the peristom, is notched, thrown into longitudinal folds, and, to all appearance, ciliated. The nucleus is always short and oval or round; its position varies; the contractile space is circular, in proximity to the beginning of the digestive tube or the œsophagus. The heap of fatty corpuscles near the base is present, as in many rigid-stem Vorticellina. The maximum length is 1-190″; and the width 1-300″. It differs from *O. articulata* (xxx. 1, 2) by its round nucleus, and from *O. berberina* (xxix. 4), which it closely resembles in its general organization, by its length and width being much nearer equal, and by its not being bent backwards on the stem when contracted. Stein describes its *Acineta* and the ciliated embryo resulting from it. The stem is subject to great varieties; but these all agree in the stem expanding from its base in a more or less marked manner, in the branches being all of equal length, and, in consequence, the zooids elevated at different heights. The stems of the oldest generations are low, and have but few animalcules upon them, which are seated on short, curved, and enormously thick branches, such as are seen in no other *Opercularia*. The whole surface of the stem is covered with numerous, closely-placed, shallow and deep transverse folds or constrictions, which give it a knotty appearance; it is also longitudinally striated. In younger generations the stems are more densely branched; but the branches are not extraordinarily thickened, being as slender as those of the larger groups of *O. articulata*, and, like these, have only here and there transverse markings,—for instance, at the angles of the branches. They are also longitudinally striped, and differ further from *O. berberina* by their expansion upwards towards the base of the superposed animalcule. On aquatic Crustacea and Mollusca.

O. *stenostoma* (Stein). — Body pyriform, widest in front of the middle line, rounded anteriorly, with a very narrow peristom, and behind the middle strongly contracted, so as to assume the appearance of a pedicle. The disc of the rotary organ is very narrow across, fringed with a single row of cilia; the membranous process from the oral cavity rises only so much above the peristom as to form a narrow annular ridge. Nucleus long and horseshoe-shaped; contractile space circular, placed near the commencement of the œsophagus. Stem branched dichotomously, but short, whence the individual animalcules (not more than 4–6 in number) are in near apposition. 1-900″; length of stem 1-360″. The stiff stem is small relatively to the body, striated longitudinally, and obscurely wrinkled transversely. On aquatic Mollusca.

O. *microstoma* (Stein) (xxx. 37). — Very similar to the last-named species. Like this, it forms a lowly-branched stem bearing few animalcules. The branches are comparatively thin, and mostly marked by thickly-set annular constrictions, rendering it more or less crooked and knotty. Some stems, however, are quite smooth, and also without trace of longitudinal striæ. The animals, when extended, are pear-shaped, and have a constriction behind the middle, and in front a very narrow peristom. Rotary organ with a short stem and a narrow disc; on the opposite side of the oral cavity is a tongue-like membranous process. The oral cavity is comparatively narrow; the digestive tube short, the contractile vesicle lies near its upper end, and the curved, hook-like nucleus behind the rotary organ. In contraction the animal retains its pyriform figure, and is thrown into annular folds posteriorly. When more strongly contracted, it becomes oval. Greatest length 1-280″; width 1-450″. On the feet of Crustacea.

O. *nutans* (Stein) = *Epistylis nutans* (Ehr.); but the description by Ehrenberg requires to be modified by the discoveries of Stein, to render it correct and characteristic. The two-lipped mouth is a misapprehension of the rotary organ and membranous process of the oral cavity, and the retractile palate is equivalent to the rotary organ of Stein.

Genus ZOOTHAMNIUM (XII. 67, 68, 69).—Comprehends Vorticellina with a spirally flexible branched pedicle having an internal muscle. The stalked corpuscles are of different shapes; a wreath of cilia surrounds the frontal region. The mouth simple and lateral. Numerous round stomach-cells (vacuoles) can be demonstrated by artificial feedings. Self-division has been observed.

The more accurate examination of Stein supplies additional details, and corrects those above, as given by Ehrenberg. The so-called frontal region is the peristom of Stein, which presents a rounded tumid border, but no cilia; for these organs form a fringe around a ciliary disc within the circumference of the peristom, which can be protruded beyond, or retracted within it. In short, *Zoothamnium*, like other Vorticellina, has a "rotary organ," which, by the whirling of its cilia, draws inward to the mouth, situated on one side of it, a current of water, together with the nutritive particles it may contain. Within are a curved semicircular band-like nucleus, a contractile vesicle, the so-called stomach-sacs or vacuoles, and numerous granules and molecules. The mouth opens into a wide œsophagus, which extends backwards towards the centre of the body, where it terminates abruptly. The stem essentially differs from that of *Carchesium* in its central canal being continuous throughout; but the distinction drawn between the two genera by Ehrenberg, from the presence of dissimilar corpuscles (animalcules) being found in *Zoothamnium*, and not in *Carchesium*, is worthless, as that circumstance is indicative of nothing more than a certain condition of development. The oldest portion of the stem in this genus often becomes solid and rigid, and thereby resembles that of *Epistylis*, for which it might he mistaken (see p. 293). Dr. Wright observes that the primary (parent) zooid of a polypary does not begin to develope the contractile band in its pedicle until this has attained a considerable length; hence, for the time, this primary zooid is an *Epistylis* by the structure of its stalk.

ZOOTHAMNIUM *Arbuscula* (*Vorticella racemosa*, M. and Duj.) (XII. 67, 68, 69) has the branches in racemes or irregular umbels; corpuscles (zooids) white, campanulate; pedicle very thick. These beautiful little trees resemble plumes of feathers. They have the characters of *Carchesium* and *Opercularia* as respects the presence of globular bodies in the axillæ of the branches, but are at once distinguished by the strength of the latter. Found upon *Ceratophyllum* and other freshwater plants, and also in sea-water; visible to the naked eye. It contracts itself on its very elastic pedicle on every alarm. It lives but a short time when removed from its native place (Brightwell, p. 344). Size 1-430"; tree 1-4", stalk one-fourth the thickness of the body.

Z. niveum (*Z. plumosum*, Wright).—Main stem zigzag; branches short, alternate, almost verticillate, given off from each angle of stem; zooids oblong, campanulate, white, clustered at the ends of the branches, which are filiform, the lower ones often deserted, while the upper bear clusters of club-shaped little bodies rounded anteriorly. Summit of main stem and branches curved backwards like an ostrich-feather; hence the name *plumosum*, proposed by Dr. Wright. 1-210".

Z. affine (Stein).—Stem dichotomous; branches attaining a nearly equal elevation. The primary stem varies in length as well as the lateral ramifications; hence the arborescent polypidom varies considerably in its general aspect, being at one time loose and diffuse, at others compact and dense. When extended, the transparent branches are smooth, but during contraction are thrown into transverse folds, and acquire a relative increase of thickness. The canal is continuous throughout, except at the base of attachment in specimens of some age, where the stem is solid; in its interior is the axis-matter,—*i.e.*, in Ehrenberg's language, the muscle moving the stem. The animalcules borne on the extremities of the branches are oval, somewhat contracted behind, and truncate in front, where they are surmounted by a thick tumid peristom of rather less diameter than that of the body. The rotary organ is strikingly narrower, and protrudes little beyond the peristom: in the course both of the extension and retraction of the rotary disc a fold is produced, which gives the appearance of a double peristom. A wide œsophagus and digestive tube opens from the mouth; and near its posterior extremity is the contractile vesicle. The nucleus resembles a short semicircular band, and lies across the body. The relative thickness of the stem is a remarkable character of this species, being one-half that of the animalcules it supports. Usual length of animals 1-380" to 1-270"; width 1-650" to 1-570". On Entomostraca, &c.

Z. Parasita (Stein).—Tree-like polypary, very small, supporting few animalcules: the latter agree in figure with those of *Z. Arbuscula*. Stein believes it identical with *Carchesium pygmæum*, Ehr., the latter being an incompletely-developed form. On Entomostraca and small aquatic Crustacea.

We are indebted to Dr. Wright for a notice of the following species:—

Z. dichotomum.—Stem very regularly dichotomous; pedicles long; zooids cylindrical, resembling fruit of the *Rosa canina*.

Z. plumosum (Wright) = *Z. niveum.*

Genus SCYPHIDIA (Duj.).—Sessile, cup-shaped, tapering at the base, covered with a reticulated integument.

This genus is received both by Perty and Lachmann. The former notices three species, of which one, viz. *Sc. patula*, is new, the two others being *Sc. ringens* and *Sc. pyriformis*. Lachmann, on the contrary, although admitting the genus, rejects the species of Dujardin and Perty, "as they have a short stem, and appear to be only particular states of pedunculate Vorticellina, in which the stem has not attained its usual length; but on the other hand," he continues, "two other beings must be referred to it, both of which attach themselves to the naked parts of small freshwater mollusca, and never form a stem, but which were often observed by me in process of division, and are easily distinguished from other forms which are, like them, attached at first, by their posteriorly-truncated form, and a projecting pad at the margin of the hinder end."

SCYPHIDIA *rugosa.*—Oblong, marked with distant oblique deep striæ, looking like furrows. 1-565″. In pond-water, amongst vegetable débris. To this genus Dujardin would also attach the *Vorticella ringens* and *V. inclinans* of Müller, and possibly also the *V. pyriformis* of the same author, under which name Ehrenberg has described a variety of *V. convallaria*.

Sc. *pyriformis.*—Grey, hyaline; with no pedicle, or an extremely short one; constantly contracting itself. Uncommon; on *Cyclops*, &c. Length, including stem, 1-720″ to 1-600″. Is closely allied to *Sc. ringens*.

Sc. *patula* (Perty).—Widely campanulate; of a bluish-grey colour; stem half the length of the body. Length, with stem, 1-360″. Uncommon, with *Potamogeton*.

Vorticella hamata (Ehr.) is probably another species, and identical with *V. inclinans*, which Dujardin numbers among the *Scyphidia*.

Sc. *limacina* (Lachmann) = *Vorticella limacina* (Müll.) (XXIX. 3).—Body nearly cylindrical, tapering a little at each end, and annulated; peristom narrow and not turned backwards; ciliary disc narrow, and furnished with a projecting umbilicus in the middle; the posterior truncated surface provided with a thick pad-like margin. 1-240″ to 1-360″. Lives on small species of *Planorbis*.

Sc. *Physarum* (Lachmann) is longer and more uniformly cylindrical than the preceding, the peristom longer and often turned backwards (everted), and the hinder margin thinner and shorter. Lives on the naked parts of species of *Physa*.

Genus URCEOLARIA (Lamark and Duj.).—Body not ciliated throughout, contractile, varying in shape from hemispherical or discoid to globular; surrounded by a plane margin fringed with a row of strong cilia planted obliquely, which makes a spiral turn inwards at the oral aperture, which is also situated on the margin.

Vorticellina of different kinds have been mistaken for examples of this genus, and Ehrenberg has placed some of its members among the *Trichodinæ*; indeed the type of *Urceolaria* is the *Trichodina Pediculus* of Ehrenberg.

Many species of this genus are parasitic on freshwater Mollusca and Zoophytes; but Müller mentions some found by him in sea-water.

There appear no sufficient grounds for instituting this genus when that of *Trichodina* is admitted, as it is by naturalists generally.

URCEOLARIA *stellina* = *Trichodina Pediculus* (Ehr.).

U. *discina* = *Vorticella discina* (M.).—Described by Müller as orbicular, hollowed out above, convex beneath . . .; the border of the disc ciliated. In sea-water. Uncommon. Ehrenberg has treated this form as identical with *Trichodina Pediculus*, but, as Dujardin thinks, erroneously. However, it is impossible accurately to decide what the being which Müller met with is, from the account he has left us.

U. *limacina.*—Sessile, cylindrical, diaphanous; orifice truncated, with 2 or 4 indistinct cilia (according to Müller), or, as we may presume, with a circlet of cilia around the margin of the wider extremity, and a collection of cilia at the narrower base, by which the animal attaches itself. Parasitic on the tentacles of *Bulla* and *Planorbis.*

U. *Dujardinii* = *Vorticella bursata* and *V. utriculata* (Müll.).—Capsular or utricular in shape, bellied posteriorly, ciliated on the anterior margin. Müller distinguished this being under two forms, one of which he described as having a projecting papilla at the centre of the anterior surface, capable of elongating itself. In sea-water.

These species of Müller appear to us too indistinct to insist on as independent forms.

Genus CHÆTOSPIRA (Lachmann) (XXXIX. 5, 6).—The surface generally covered with cilia, like the genus *Stentor,* from which it is distinguished by having that part of the parenchyma of the body which bears the ciliary spiral and the anus (which in all the Stentorinæ lies on the dorsal surface of the body, close under the ciliary spiral, and not in a common pit with the mouth) drawn out into a thin process. This process is narrow and bacillar; the series of cilia commences at its free extremity, and only forms a spiral when in action by the rolling-up of the lamina. The process bears the anus. The animalcules inhabit a sheath or tube, of a mucilaginous or even horny density. "It is possible that the free-swimming *Stichotricha secunda* of Perty, which he arranges with the Oxytrichinæ, is allied to *Chætospira*; his figure, however, is very inexact, and might perhaps represent a Loxodes or *Amphileptus Fasciola*; and, as he does not describe the position of the anus, which he never figures, any more than the contractile vesicle and the nucleus, I do not venture to place his *Stichotricha* with the Stentorinæ. If it should turn out that it belongs to that family, it must be placed beside the analogous sheath-inhabiting *Chæstospira,* as a genus not inhabiting a sheath."

Chætospira *Mülleri* (xxix. 5, 6).—Slender. The first cilia of the series upon the process are somewhat, but not remarkably longer and stronger than the rest; when rolled up, the ciliated bacillar process forms more than one turn of a spiral. Sheath flask-shaped and horny. Hitherto found only in the open cells of torn leaves of *Lemna trisulca,* growing in fresh water near Berlin.

Ch. *mucicola.*—Enclosing tube mucous in consistence; animalcule shorter and more compressed; the rolled-up ciliary process does not form a complete turn of a spiral; the first cilia are considerably larger than the rest, the first one especially being nearly twice as long as most of the others.

Genus CŒNOMORPHA (Perty) (XXVIII. 27–30).—Small, hyaline, of a bell-like or hemispherical figure, concave at its truncated base, which has an irregularly notched margin, and a tail-like process depending from it at its centre. Rim of the bell furnished with long cilia. Except in the absence of the long tentacula, these beings, according to Perty's figures, have a general resemblance to minute campanulate *Medusæ*; or, otherwise, they may be likened to miniature parasols with fringed edges and a short handle.

Perty has placed this genus in his family Urceolarina, which is equivalent to that called Stentorina by Lachmann. But, to our mind, much doubt must attach to this assigned position, for not only is there a very great departure from the general form of every genus of Vorticellina, as Perty himself could not fail to remark; but, from his figures, no characteristic, no internal organization appears to establish the organic affinities of these curious beings.

CŒNOMORPHA *Medusula* (XXVIII. 27–30).—Colourless, transparent, with a small number of internal vesicles and molecules. Length, together with the tail, 1-240″ to 1-190″. It swims actively and rotates on itself, undergoing various changes in outline. Some specimens exhibit folds of the surface.

Genus SPIROCHONA (Stein) (XXX. 17–20, 27, 28).—Body naked, but having a firm corneous integument; attached perpendicularly by its base, and quite motionless; of an elongated, flask-like shape, with an anterior, spirally-convoluted, funnel-like head or peristom. Posteriorly it narrows to a small base, whereby it is fixed either immediately or mediately by a very short pedicle. The infundibuliform spiral peristom surmounts a constricted portion or neck. The spiral lamina forming the peristom terminates abruptly below, so as to leave a cleft, which conducts to the mouth; its upper portion is rolled around the longitudinal axis of the peristom, and produces a solid central pivot. The innermost turn of the lamina constitutes a funnel, which surmounts the whole peristom, and with the next coil forms what Stein calls the "spiral funnel," whilst the lowest and widest spiral represents the true peristom, homologous with the ciliary spiral or peristom of *Vorticella*. The latter is richly covered with cilia, which extend in less number to the second coil. Internally, a digestive tube is seen to extend a considerable distance from the mouth, having a contractile vesicle placed near its termination. A large nucleus is seated near the middle of the animal, having a clear central space or nucleolus. Fission has not been witnessed; but gemmæ are frequently produced, which, under certain circumstances, become encysted, and, as Stein believes, undergo an Acinetiform metamorphosis (XXX. 21–28). Length 1-750″ to 1-216″; breadth of largest 1-600″.

SPIROCHONA *gemmipara* (XXX. 17–20).—The above description applies specially to this form. Found on the ova-capsules of *Gammarus* and other Entomostraca, in fresh water.

SP. *Scheutenii* (XXX. 27, 28) agrees with the foregoing in size and figure; but the peristom is more simple, consisting of little more than a single coil of a wide lamina, and has, besides, a series of stiff fibrous processes fringing it on one side. The internal face of the funnel is lined with cilia below. Found on Entomostraca in brackish water near Amsterdam by M. Scheuten; they are attached to the long feathery bristles of the post-abdominal feet, and not to the ova-capsules, like *S. gemmipara*.

FAMILY IV.—OPHRYDINA (VAGINIFERA).

(XXVII. 10–15; XXVIII. 18–20, 23; XXX. 29–35.)

Loricated polygastric animalcules, solitary or aggregate, possessing a distinct alimentary canal, a separate mouth and discharging orifice, which approximate and terminate in the same spot. In organization it resembles the family Vorticellina; in fact, continues Ehrenberg, it includes true *Vorticellæ* or Stentors, enclosed in a gelatinous, membranous, combustible lorica. Besides the usual frontal wreath of cilia, there is in *Ophrydium* a second wreath placed posteriorly; and *Tintinnus* has an elastic muscular stalk or tail. Although, as Ehrenberg tells us, the polygastric organs of nutrition can be demonstrated in all the tribe by using coloured food, it is only in *Ophrydium* that an alimentary canal has been distinctly seen. Longitudinal division of the body takes place within the lorica, which continues unaffected. In *Ophrydium* transverse division has been doubtfully affirmed.

The genera are disposed as follows:—

Forming Monad-clusters, through incomplete self-division of the lorica......			Ophrydium.
Animalcules solitary, no self-division of the lorica	Body furnished with an elastic pedicle attached to lorica		Tintinnus.
	Body stalkless......	Lorica stalkless	Vaginicola.
		Lorica stalked..............	Cothurnia.

Of the genera composing this family, *Ophrydium* is arranged by Dujardin with the Urceolarina, and *Vaginicola* with the Vorticellina. This author writes—

"The sô-called lorica of *Ophrydia* (Duj., or *Ophrydium*) is an amorphous gelatinous investment, unlike that of *Vaginicola*, which is a truly resistant enveloping membrane. The individual beings in the gelatinous ball of *Ophrydia* are elongated, cylindrical, or fusiform, and capable of varying their figure."

Further, Dujardin includes *Tintinnus* and *Corthurnia* in the genus *Vaginicola.*

Stein enumerates *Tintinnus* among the genera of Ehrenberg's Ophrydina, but offers no account of it. He rejects the distinction, as does Dujardin, between *Vaginicola* and *Cothurnia*, and would transfer the whole of this family, so reduced, to Vorticellina, with which its members have the greatest similarity in organization. Perty adopts the the title Ophrydina, but comprehends under it only the single genus *Ophrydium*. Lachmann rejects *Tintinnus* from the list.

The characters laid down by Ehrenberg, of this family, are very unsatisfactory. Its members cannot be said to be loricated in the same way as Colepina or Euplotina; for in these the lorica consists of a thickened, closely-adherent integument, whilst in Ophrydina the structure so called is a loose sheath, open at one extremity, which may in some be seen gradually excreted from and built up around the animalcule, which last, moreover, has a distinct integument of its own. In the Ophrydina, therefore, it is rightly called a sheath, case, or tube. *Ophrydium*, indeed, is exceptional; for, though it secretes a large quantity of muco-gelatinous substance, it never builds this up around it into a sheath, but merely sends into it a long, tapering, fibrous prolongation from its posterior extremity to secure a firm hold, whilst its body projects freely from the mass (see Part I. p. 282). Moreover, it is this genus only that is aggregated, all the rest being solitary. These peculiarities may be held to justify Perty in erecting this genus into a family.

The presence of numerous stomachs and of a distinct alimentary canal, it need only be said, are details of organization required by the hypothesis of Ehrenberg, and supposed in some instances to be demonstrated by feeding with colouring matters.

As Ehrenberg rightly intimates, Ophrydina may be briefly defined as Vorticellina living in a sheath, instead of being supported on a pedicle. From this general definition *Ophrydium* is necessarily excluded as an exceptional form; and it becomes, therefore, a matter of regret that a family should be named from a genus in no sort its true type. Perty has invented the name "Vaginifera" for a family containing the two genera *Vaginicola* and *Cothurnia*; and it is certainly preferable to Ophrydina, whether *Ophrydium* be comprehended in it or not.

Genus OPHRYDIUM (XXX. 5, 6).—Lorica gelatinous; animals clustered, in consequence of perfect self-division of the body, but imperfect of the lorica. This circumstance gives rise to very peculiar external appearances;

for each body very frequently divides itself, the two portions separating entirely,—the gelatinous lorica forming only a separating wall. In this manner thousands and millions of connected animal-cells are quickly formed, appearing as gelatinous globular masses or balls.

It is a misapprehension, on the part of Ehrenberg, of the actual phænomena, when he states that the large gelatinous ball formed by the multiplication of *Ophrydia* is the result of imperfect fission of the lorica; for, as we have pointed out, the animalcules have no lorica or sheath in the sense Ehrenberg intended, but are merely attached by a sort of non-contractile stalk penetrating far in the interior, upon the surface of the gelatinous mass. When fully contracted, indeed, it is drawn down upon and slightly presses into the soft mass, raising this as a rim around it; consequently it is also an error to say that the mass is composed of numberless little cells, seeing that nothing like a cell is constructed around the animalcules. Stein found within the interior of the gelatinous mass numerous intertwining and twisted fibres, which he concluded were vegetable parasites, probably of the family Leptomitæ. Agardh and other botanists have described the gelatinous balls of *Ophrydium* as a species of Nostochineæ, under the name of *Nostoc pruniforme;* but this is a great mistake, for no cellular or proper vegetable structure is present.

Stein has added to the vaginated Vorticellina, or the Ophrydina, the genus *Lagenophrys*; and Dr. Wright (*Edin. New Phil. Journ.* 1858) the interesting genus *Lagotia*.

OPHRYDIUM *versatile* (*Trichoda inquilina* et *Vorticella versatilis*, M.) (XXIII. 5, 6).—Body fusiform, tapering to a fine extremity from behind the middle, and anterior to it contracted into a cylindrical neck, supporting a funnel-shaped head surmounted by an annular peristom with a ciliated rotary disc. The mouth opens into a narrow and long ciliated œsophagus. The contractile vesicle is seated near its end; the nucleus is long, narrow, and twisted. The external surface is thrown into close annular folds; and usually three longitudinal plaits extend from the posterior end as far as the middle of the body, which disappear when the body contracts. A subjacent cortical lamina is evident, and, imbedded within this, numerous chlorophyll utricles, giving the animal a vivid green colour. When contracted, the body assumes the form of a long-necked flask, and even the nucleus shortens itself. In more complete contraction the figure becomes oval or globular. Fission is only longitudinal; when an *Ophrydium* quits its hold after fission, it swims away by means of a temporarily developed posterior wreath of cilia, just like a *Vorticella*. It is found encysted, and, Stein believes, in an Acinetiform phase (XXX. 7, 8). Vividly green, and associated in smooth and globular clusters or masses, which vary in size from a pea to a ball five inches in diameter; they are either free or attached. Ehrenberg states that, in May 1837, he saw hundreds of clusters as large as the fist, which, by the evolution of gas, were at intervals elevated to the surface, and driven by the wind to the edge of the water. In sea-water; also found by Brightwell in fresh water, and in a small turf-pit, upon tendrils of roots of marsh-plants, and the stalks of the white water-lily. Length of single animalcule stretched out, 1-120″ to 1-90″.

Genus TINTINNUS.—Ophrydina which possess divisibility of the body, but not of the urceolate lorica; the body is attached to the interior of the sheath by a flexible pedicle (somewhat similar to the clapper of a bell); the mouth serves both as a receiving and discharging orifice; stomach-cells and traces of a yellowish ova-cluster are more or less visible; self-division was known to Müller.

Tintinnus, as before noted, is a genus not admitted by Dujardin; Perty likewise ignores it; and Lachmann (*A. N. H.* 1857, p. 119) feels the necessity of excluding it from Vorticellina (using this term in a wider sense, so as to include Ophrydina), since it is ciliated all round, and differs greatly from them in the form of its alimentary apparatus. Moreover, a species inhabiting a gelatinous sheath occurs in the freshwater ponds in the Thiergarten at Berlin.

TINTINNUS *inquilinus*.—Hyaline or yellowish; lorica cylindrical, glass-like, bell-shaped. 1-570″, with stalk 1-240″. In sea-water, on Algæ.

T. *subulatus* (*Vorticella vaginata*, M.).—Hyaline; sheath conical, with a posterior subulate elongation. Ehrenberg observes that, if this elongation of the lorica were called a stalk, we should require a new generic name for the animalcule. Length of lorica 1-90″.

T. *Cothurnia*.—Hyaline; sheath cylindrical, hyaline, indistinctly annular; rather attenuate and truncate posteriorly. 1-440″. In the Baltic.

T. *Campanula*.—Hyaline; sheath widely campanulate, dilated in front, pointed behind. 1-290″. In North Sea and Baltic.

T. *denticulatus*.—Sheath cylindrical, hyaline, sculptured with oblique rows of dots, front margin acutely dentate; posterior extremity pointed. 1-220″. In the North Sea.

Genus VAGINICOLA (XXVII. 10, 11; XXVIII. 18, 19).—Neither the body nor the lorica stalked; a wreath of cilia surrounds the truncated front portion, within which is the orifice or mouth. The polygastric apparatus, the passage of the food onwards, its return, and the exit of the refuse near the mouth, and coloured ova-granules, are mentioned by Ehrenberg. Increase by longitudinal self-division of the body (not of the lorica) has been seen in all the species.

To the above account must be added, according to Stein's observations, that the body of *Vaginicola* has in front a peristom, from out of which a "rotary apparatus" protrudes, consisting of a ciliated disc, supported on a stout stem or pedicle, just like that of *Vorticella*. A mouth opens on one side of the disc, and leads into an œsophagus; but no polygastric structure, as surmised by Ehrenberg, is visible, although numerous alimentary vacuoles are usually present. Ova-granules, again, are merely hypothetical, and, as in other Infusoria, where mentioned by Ehrenberg, represent particles of various kinds, but mostly coloured granules. In a new species noted by Dr. Wright, the tubular sheath has a peculiar structure in the form of a valve, which closes over the animalcule when it retreats to the bottom of its case (XXVIII. 18, 19).

In all the particulars of internal organization, *Vaginicola* resembles *Vorticella*. Propagation by fission and gemmation is very distinct; by the former process more common (XXVII. 10, 11). The development of the bud takes place from the base of the parent, and within its sheath. The young being, produced by either process, is furnished, as in *Vorticella*, with a posterior wreath of cilia, whilst it is endowed with free locomotion (XXVII. 11). It frequently happens, as represented in the last-quoted figure, that the young being assumes on its formation a contracted ovoid form, with its frontal wreath retracted. Upon the appearance of the posterior whorl of cilia, and aided by its movements, the animal loosens itself, escapes from the parent-case, and swims freely away, elongating itself, it may be, if previously contracted, and assuming finally all the characters of a perfect *Vaginicola*, by developing around it its own special sheath.

On the other hand, the contracted individual may become actually encased within its integument (in other words, encysted), and, as Stein believes, may thereupon assume all the characters of an *Acineta*, and eventually give birth to a ciliated embryo (XXVII. 11–15). This metamorphosis, however, is not generally accepted. The specific characters in this genus are for the most part deduced from the figure and dimensions of the external sheath or lorica (Ehr.), and must, therefore, as Stein points out, be admitted with much reservation; for this envelope changes greatly in figure, in size, and structure, according to the age and the different vital conditions under which the animal lives. Stein met with one example in which a short pedicle attached the *Vaginicola crystallina* to the bottom of its sheath: indeed he does not admit *Cothurnia* and *Vaginicola* to be generically distinct; for the stems supporting the sheath of the former are, he says, not generally longer than those belonging to young *Vaginicolæ*. In this point therefore he agrees with Dujardin.

We have observed how close the resemblance is between *Vorticella* and *Vaginicola*; on the other hand, the points of separation are found in the absence of a pedicle in the latter, which is fixed to the bottom of a sheath by its posterior extremity, its anterior remaining free, and its whole body capable of extension or retraction within the orifice of its case. Lastly, the figure of the body is much more elongated in *Vaginicola* than in *Vorticella*.

VAGINICOLA *crystallina* (*Vorticella stentorea* et *Trichoda ingenita*, M.) (XXVII. 10, 11).—Sheath crystalline, straight, pitcher-shaped, slightly contracted near the open end; granules green. Length of lorica 1-210″. Upon *Lemna*, &c.

V. *tincta*.—Sheath brownish-yellow, urceolate, and nearly cylindrical; body hyaline. Length of lorica 1-280″. Upon *Zygnema decimum*.

V. *decumbens*.—Sheath brownish yellow, oval and compressed, decumbent on one side, which is flattened; the body hyaline. Length of lorica 1-280″.

Stein corrects this description by stating that the oval plano-convex sheath has not a simple crescentic opening, but is contracted so as to form a short tubular neck, or projecting process, with a transversely oval or reniform mouth. It has consequently the closest resemblance to the sheath of *Lagenophrys Ampulla*; but its orifice is rigid, and not contractile as in the latter, and, further, the animalcule is not affixed to its margin, but to the bottom. On *Lemna*, *Zygnema*, &c.

V. *valvata* (Wright) (XXVIII. 18, 19).—Distinguished from *V. crystallina* by the remarkable valve existing in its case or sheath—which closes, in an inclined position, over the animal when it retreats to the bottom of its case; by the body being colourless, without the green globules seen in *V. crystallina*; and by being an inhabitant of sea-water instead of fresh. Plentiful on zoophytes and seaweeds.

V. *vaginata*.—Under the name *Vorticella vaginata*, Müller described a *Vaginicola* found in the Baltic, having a delicate pedicle as long as the body, which is supported by it, at the upper end of a sheath six times longer than itself, into the orifice of which it can with difficulty enter.

V. *pedunculata* (Eichwald).—Body attached to the bottom of the sheath by a short stem. This presumed species is actually nothing more than a variety of *V. crystallina*, as Stein has shown.

V. *Ampulla*.—Müller described this as larger than most animalcules, as dwelling in a bottle-shaped sheath, as very contractile, grey, and soft, and as occupying various positions within the case. Found in the Baltic, and, by Mr. Brightwell, at Lowestoft. Dr. Wright (*Edin. Phil. Journ.* 1858, p. 5) says it has a bilobed ciliated organ, and so far resembles *Lagotia*.

V. *ovata* (Duj.).—Body of a lengthened ovoid figure, placed in an urceolate case. Length of body 1-1000″, of case 1-550″. Apparently distinct from *V. crystallina*. On *Zygnema* in pond-water.

V. ——? (Brightwell) (XII. 70).—Body double, of a green colour. Probably undescribed. On duck-weed and other small aquatic plants. It is doubtful whether this being is other than a *Vaginicola* in process of spontaneous fission.

V. *grandis* (Perty).—Sheath cylindrical. Animals with a circular ciliated opening. Length of tube 1-108″, of the extended animal 1-84″. Stein considers this species a mere variety of *V. crystallina*; but besides differing from it in size, it does so also in the figure of its sheath, which is not rounded below, but abruptly truncate, and not narrower above, but rather wider. Animalcules hyaline, often filled with sporozoids and chlorophyll granules; when contracted it does not occupy more than a third of the tubular sheath. Among water-plants. Uncommon.

The figure of this species presented by Perty is very rude, conveying not the slightest conception of the details of external structure or of internal organization.

Genus COTHURNIA (XXX. 12–16).—Lorica (sheath) urceolate, and supported on a rigid pedicle. A wreath of cilia is placed upon the flat frontal region; and the mouth, with the anal opening, lies on one side, within the vestibulum. The body is contractile, and can withdraw itself within the stiff sheath; fission longitudinal.

It is unnecessary to enlarge on the structural details of this genus, inasmuch as they are in all particulars like those of *Vaginicola*, from which it is separated only by its sheath being stalked.

COTHURNIA *imberbis* (*Vorticella folliculata*, M.).—Pedicle mostly bent and much shorter than the sheath, which has, when old, a yellowish colour. Sheath tubular, narrowed anteriorly, without an everted margin. Even when outstretched, the animal extends little beyond the mouth of the sheath; its peristom is scarcely appreciably thickened, and not everted at all; it is evidently ciliated. The disc of the simple rotary organ is level on its surface, and scarcely rises above the sheath. Digestive tube long and narrow, extends beyond the centre of the body, and near its commencement has from 3 to 4 long cilia. Near to it, on one side, is a round contractile vesicle, and on the other a short, band-like nucleus, almost straight or slightly reniform in figure. Longitudinal fission frequently observed, and sufficiently often the process of gemmation at the base. Length of sheath 1-288″ to 1-240″.

Ehrenberg remarks, "This animalcule had often swallowed green Monads, and yet accepted indigo. *Trichodina vorax* is the enemy of this species." Upon *Cyclops quadricornis*. Length of sheath 1-280″.

C. *maritima*. — Pedicle much shorter than the hyaline sheath; body hyaline and whitish. Length of sheath 1-570″.

C. maritima is very closely allied to *Vaginicola crystallina*: not the least difference between the animals themselves is perceptible, and the figure of the sheath is the same,—the only essential difference being that in the *Cothurnia* the sheath is supported on a thin, solid stem, 1-48″ to 1-36″ in diameter and of a length equal to its own.

C. *Harniensis*.—Pedicle much longer than the hyaline sheath; body whitish. Length without stalk 1-280″.

C. *Sieboldii* (Stein) (xxx. 13, 14).—Sheath stalked; stalk short, thick, colourless, transversely and deeply wrinkled, and thickened at its junction with the sheath. The last is campanulate, strongly compressed in front, dilated and bellied out posteriorly, especially on the dorsal aspect. The two angles in front are extended upwards and outwards, but at the same time curved inwards at their extremities as two horns. The walls of the sheath are at first soft, colourless, and hyaline, but subsequently become yellow and leathery, and at last of a more or less deep rusty brown colour, and of a corneous consistence. The colourless and, with reference to the sheath, small contained animal is cylindrical in figure, contracted behind, and very similar to that of *Vaginicola crystallina*. Its peristom forms an annular thick border, and is beset with few cilia. The digestive tube, which extends to nearly the centre of the body, has close to it the contractile vesicle, and a little further behind, the thick, short band-like and semicircular nucleus, visible without the use of chemical reagents. Multiplication takes place by longitudinal fission. Length of largest sheaths 1-190″. On the limbs and other parts of Entomostraca; very abundantly.

C. *Astaci* (Stein) (xxx. 15).—Sheath supported on a short, wrinkled, thick pedicle; having itself a tubular figure, rather contracted at the middle, and its border widened and everted, whilst its posterior half is slightly ventricose and rounded at its extremity. Its consistence is leathery or horny when old; it is transparent and of a pale yellow colour, but never a rusty brown. When fully outstretched, the animal protrudes a considerable distance beyond the mouth of the sheath, differing in this respect, as well as by its thick annular peristom and its cylindrical outline, from *Cothurnia imberbis*. The digestive tube attains the middle of the animal, is very narrow, and has both the contractile vesicle and the short band-like nucleus placed near its termination. Fission is longitudinal.

Old specimens attain a height of 1-288″, and a width of 1-600″. Also found on Entomostraca. It is very closely allied to *C. imberbis*; but, besides the differences noted between the animalcules, the stem of the latter is relatively thinner, the posterior extremity of the sheath pointed, and the anterior contracted.

C. *curva* (Stein) (xxx. 12) resembles generally a contorted specimen of *C. Astaci*; but old specimens have rusty-red-coloured sheaths. The pedicle of the sheath is always curved; the anterior third of the sheath is bent outwards, and the posterior half ventricose, particularly on the dorsal surface. The bending to one side causes the mouth of the sheath to be oblique. The contained animalcule agrees generally with that of the two preceding species. Length of sheath 1-360". Upon the ova-lappets of Entomostraca.

Stein doubts the independence of this species; for, besides being imperfectly observed by Ehrenberg, it is exceptional in the animalcule not being fixed at the bottom of the sheath.

C. *Pupa* (Eichwald).

C. *perlepida* (Bailey).—Apex of sheath attenuated, slightly curved; surface entirely covered with spirally decussating rows of hexagonal cells; orifice crenulate. Contained animal unknown. St. George's Bank and New Haven Harbour, New York.

C. *Floscularia* (Perty).—Hyaline; the cilia of frontal segment collected in two groups, recalling thereby the aspect of the ciliary apparatus of a *Floscularia*. Sheath of the same form as that of *C. imberbis*. The animal lives much in a contracted state within its sheath, and extends itself very slowly: on the contrary, the act of contraction is rapid. 1-260". Among *Callitrichæ*.

Genus LAGENOPHRYS (Stein) (XXX. 29-36).—Sheathed Vorticellina, differing especially from *Cothurnia* and *Vaginicola* by the zooids being attached to the circumference of the mouth of the sheath, and freely dependent from it, instead of being affixed to the bottom as in those genera. The sheath itself is without pedicle, and adheres to foreign bodies by one side, as does that of *Vaginicola decumbens*: this side is flattened, and may be referred to as the abdominal surface. The opposite side, or the back, is strongly vaulted. The mouth of the sheath is very much narrowed, and furnished with a prominent, flexible, double lip, which can be closed when the contained animalcule contracts itself. This last is closely adherent by its peristom within the margin of the orifice of the sheath, and has generally the same figure as the sheath, but not the same dimensions; hence it lies loosely within it. The mouth of the sheath and the peristom are of equal diameter; and through them a long stalked rotary organ projects, terminated by a circular ciliary disc. When the animal contracts, the rotary apparatus is withdrawn, the peristom closes like a sphincter, and the two-lipped mouth of the sheath by its closure completes the security of the whole being. Reproduction takes place by oblique fission and by gemmation.

LAGENOPHRYS *vaginicola* (xxx. 29-36).—Sheath elongated cordate; in the centre of its broader and truncate end is the circular orifice, having two semicircular, prominent, valvular processes, which collapse together when the contained animalcule contracts itself. The contracted posterior extremity has a very thick wall. The enclosed animal is ovate, and adherent by its narrow peristom to the orifice of the sheath, and leaves a large interspace posteriorly between itself and the enclosing wall of its sheath, except when it retracts itself. The young formed by gemmation, as well as the products of fission, can escape only when the parent being loosens its attachment from the aperture of the sheath, and so furnishes an outlet. The medium length of sheath is 1-380"; the greatest width 1-640". On *Cyclopsina staphylina*.

L. *Ampulla*. — Sheath resembles a plano-convex circular lens, except in having an anterior projecting everted rim around the oral orifice. The animalcule has the same figure as the sheath, and an internal organization like that of the preceding species. Diameter from 1-480" to 1-360". On aquatic animals, Entomostraca, and the like.

L. *Nassa*.—Very similar in figure and size to *L. Ampulla*, but has a different profile or lateral outline. The sheath, although nearly spherical, is plano-convex, somewhat truncate in front, and emarginate on the upper surface, as is best seen in profile. The mouth of the sheath is prolonged as a cylindrical, two-lipped process, capable of being retracted. Is more rare than *L. Ampulla*, but, like it, occurs on *Gammarus* and other aquatic animals.

Genus LAGOTIA (Wright) (XXVIII. 20–23; XXXI. 7, 8).—Sheath or case retort-shaped, with a cylindrical neck, plain or annulated; colourless, yellowish, or dark green; body long, cylindrical, attached by its posterior end to the bottom of the case, terminated anteriorly by a forked (furcate) head, or two long, flattened ciliated processes, between which is the opening of the oral cavity, which extends backward into the body as a tapering œsophagus, ciliated on its free surface. The green colour of the body in *L. viridis* is not due to dispersed globules, but to a staining of the sarcode itself. Longitudinal fission has not been seen; but development by a free ciliated embryo, very unlike the parent, has been observed in *L. producta*.

LAGOTIA *viridis* (XXVIII. 20–23).—Case resembles a flask or amphora lying on its side, having the neck bent more or less sharply upwards, and dilated into a trumpet-shaped mouth. Its colour is dark sea-green, in the larger specimens nearly opake. Animalcule green, cylindrical; its ciliated organ, when seen in front and erect (f. 23), appears like a narrow horseshoe; whilst from the side (f. 21) the anterior extremity of the animalcule bears a resemblance to the head and ears of a hare—a likeness increased by the wagging movements of the long processes. In young specimens the lobes of the furcate process are blunt and short, and the ciliary band, along which the cilia are arranged, is placed at a little distance from their margin (f. 20), instead of being close to it (f. 22). Plentiful on marine shells and Algæ, Firth of Forth and Tynemouth. Embryonic development has been detected by Dr. Wright in this species.

L. *hyalina*.—Colourless; lobes of ciliated organ wider and blunter than those of *L. viridis*; cell buried in the substance of the shell of *Alcyonidium hirsutum*, and therefore not seen. Granton and Queensferry.

L. *atro-purpurea*.—Colour of animal that of a mixture of ink and water. Cell yellowish-brown. Probably a variety in colour of *L. viridis*, with which it was found.

L. *producta* (XXXI. 7–13) (Dr. Wright *in lit.*).—Neck of sheath exceedingly prolonged, annulated; sheath of a pale yellow-brown colour. Animalcule (zooid) two or three times the length of the sheath, attenuated; ciliated lobes erect, divergent, and recurved at tips; colour of zooid deep blackish green.

Dr. Wright observed the development in this species of ciliated embryos, which, after passing through the stages seen in figs. 9 and 11 (XXXI.), and carrying on an active existence as free ciliated animalcules, form an attachment to some surface and proceed to develope a sheath and the characteristic ciliary lobes. The transformation from ciliated embryos to *Lagotiæ* transpired in the course of a night,—the sheath even, during that time, being completed with its rings. The above fact constitutes an interesting addition to the illustrations of embryonic development among Ciliata, quoted in the section on that subject (p. 353).

FAMILY V.—ENCHELIA.

Animalcules having a distinct alimentary canal, with an oral and an anal orifice at the opposite ends of the body; without lorica. Locomotion effected by vibratile cilia in all the genera except three, viz. *Actinophrys*, *Trichodiscus*, and *Podophrya*, in which it is performed by slow-moving feelers (tentacles). In all but these exceptional genera, organs of nutrition have been demonstrated by the employment of coloured food; but only in one has the entire course of an alimentary canal been traced, though in most its transit through the body is indicated by its discharge through the posterior outlet. Ehrenberg states that the polygastric structure is to be seen in all the genera except the Arabian genus *Disoma*. A nucleus and vesicle are generally present. Complete self-division, both longitudinal and transverse, has been observed; but not gemmation. The most curious animalcules among them are the double-bodied *Disoma* and the teeth-bearing *Prorodon*.

The genera are distributed as follows:—

Teeth absent.	Surface of body destitute of vibratile cilia	Direct truncated mouth (no lip) ...	Vibratile cilia at the mouth ...	Body simple		Enchelys.
				Body double		Disoma.
			Ray-like tentacula not vibratile	Stalkless	The body covered with rays	Actinophrys.
					Rays at the edge	Trichodiscus.
				Stalked		Podophrya.
		Oblique truncated mouth (with lip)	No neck			Trichoda.
			With neck			Lacrymaria.
	Surface of body with vibratile cilia	Oblique truncated mouth, with lip				Leucophrys.
		Direct truncated mouth, no lip				Holophrya.
Teeth present..						Prorodon.

In the arrangement of Dujardin, and under his fourth order—comprehending " ciliated Infusoria without a contractile integument, and with or without a mouth "—a family having a similar name, Enchelina (Enchelyens, so-called after a genus *Enchelys*) is instituted. But, most unfortunately for science, this family and this genus, with respect to the animalcules they include, in no way correspond with the similarly-named family and genus of Ehrenberg. This is remarked by Dujardin himself; and he adds, with reference to the genus *Enchelys* (Ehr.), that, in the whole course of his observations, he never met with any Infusoria bearing the characters attributed by Ehrenberg to that genus, and he is led to conclude that the beings intended are *Paramecia* with a terminal mouth, or else *Bursariæ* imperfectly examined, and the cilia of the surface overlooked.

The family Enchelina is thus briefly characterized by Dujardin:—" Animals partially or entirely covered with cilia, dispersed over the surface irregularly; mouth wanting."

The family Cyclidina (Ehr.) seems, indeed, much more nearly allied to the *Enchelys* of Dujardin; but its characters, as given by Ehrenberg, are not sufficiently definite to attempt an identification.

Stein severely blames Dujardin for the transposition of generic names he has been guilty of in the case of this genus and *Cyclidium*; for, as he justly observes, it is a proceeding productive of confusion and error. The *Enchelys nodulosa*, he adds, is the *Cyclidium Glaucoma* (Ehr.), and scarcely distinguishable from *E. triquetra* (Duj.). *Acomia Ovulum* seems nothing else than *Cyclidium Glaucoma*, and *Uronema marina* another closely-allied form, and, like *Glaucoma* itself, the embryo of some other animalcule. The three remaining species of *Enchelys* enumerated by the French writer, viz. *E. corrugata*, *E. subangulata*, and *E. ovata*, are so imperfectly observed as to be worthless, and their union in the same genus with *Glaucoma* quite unwarrantable.

Yet, if Dujardin has proceeded very incautiously in rejecting the Enchelia of Ehrenberg and in redistributing its genera, no apologist of the Berlin naturalist would contend that it should be left as it is; for every person having any acquaintance with the beings brought together as Enchelia will be struck with their heterogeneous characters. *Actinophrys*, *Trichodiscus*, and *Podophrya* belong evidently to a type of beings altogether different from the ciliated animalcules included in the family; and we have consequently treated them as an entirely separate group from the ciliated Protozoa in our general history, and have likewise, in the present portion of the work, given their systematic descriptions apart. The genus *Disoma* is a very doubtful member of this family, and is even marked as such by Ehrenberg, who had very imperfectly examined it.

The family Enchelia does not enter into the system of Perty, who disperses its members among different families according to his appreciation of their several affinities. Among the rest, his family "Tapinia" includes some species of *Leucophrys* of Ehrenberg and the genus *Acomia* of Dujardin, along with several newly-constructed genera, the account of which will be annexed to this present group.

The Family "Tapinia" is thus characterized:—

"Cilia scattered at large, or collected in groups, but not arranged in rows. Animals mostly very small. Mouth not apparent, but its presence revealed by the admission of food." This group includes the genera *Acropisthium*, *Acomia*, *Trichoda* (Duj.), *Leucophrys* (Ehr. ?), *Cyclidium*, *Bœonidium*, *Opisthiotricha*, *Siagontherium*, and *Megatricha*.

Another allied family, called "Apionidina," contains a species of *Leucophrys* (Ehr.). Perty assigns it the following characters:—"Family Apionidina: Body small, soft, thicker at one end than the other; cilia in longitudinal rows; mouth, where visible, situated at the anterior end." The genera comprised are *Ptyxidium*, *Colobidium*, and *Apionidium*. The first-named genus has, as its type, the *Leucophrys pyriformis* (Ehr.); but the other two are advanced as new genera, founded on newly-observed beings.

Both in this family (Apionidina) and in that of Tapinia, several supposed new genera are established by Perty, which, to render our compendium complete, we are bound to notice and describe, although we regret to record such a multitude of genera and names, as we feel highly doubtful of their claim to consideration as independent beings.

Genus ENCHELYS (XXVIII. 64, 72, 73).—Vibratile cilia upon surface wanting; mouth terminal, truncated (direct, not oblique), devoid of teeth; surrounded by a wreath of cilia. An œsophagus is not seen except during the passage of food. An anus is found in all, and in *E. Farcimen* a contractile bladder. Self-division is transverse and complete.

Dujardin defines his genus *Enchelys* as having a cylindrical, oblong, or ovoid body, covered with erect uniform cilia, irregularly disposed.

Cohn (Siebold's *Zeitschr.* 1851, B. iii. p. 273) treats this genus as synonymous with *Enchelys* (Duj.), and believes that several of its assigned species are not independent animalcules, but embryos of *Loxodes*, *Oxytricha*, and allied genera.

ENCHELYS *Pupa* (M.) (XXVIII. 72, 73).—Turgid, club-shaped, attenuated anteriorly; filled with greenish vesicles, or only with molecules; neither a nucleus nor a vesicle could be found by Ehrenberg. Ehrenberg has figured (in his large work of 1838) the presumed form of the polygastric nutritive system of this species separately, stating it to be remarkably distinct. Common in stagnant bog-water. 1-140″.

E. *Farcimen* (*E. Farcimen* et *Vibrio intestinum*, M.) (XXVIII. 64, *a*–*k*).—Smaller, more cylindrical and slender than the preceding; granules whitish. These creatures prey on other animalcules nearly as large as themselves, which they devour entire; this will account for the variety of forms which they assume, and which require an observer to be very watchful and cautious before he can pronounce on the identity of a species. Ehrenberg, by patient observation, saw one individual undergo a great variety of forms in the act of swallowing a young *Kolpoda Cucullus*;

illustrated in fig. 64, *a–k*. In stagnant water. 1-430″.

E. *infuscata*. — Oval or spherical; whitish; mouth not prominent, encircled by a brownish ring. When fed with indigo, numerous vacuoles become filled. In bog-water. 1-280″ to 1-240″.

E. *nebulosa* (M.). — Ovate, hyaline; mouth projecting. This species receives carmine and indigo very readily. 1-230″ to 1-570″.

E. nodulosa (Duj.) = *Cyclidium Glaucoma* (Ehr.). *E. triquetra* (Duj.) is a mere accidental variety of the same animalcule.

Genus DISOMA (?).—Body double, destitute of cilia; oral extremity truncated (direct); mouth ciliated, devoid of teeth. Within the bodies numerous little vesicular cells (stomachs) are observed, and the discharge of excrement may be seen to take place at the posterior extremity of each body.

As already noticed, this is a very imperfectly-examined and doubtful genus. The being described may be interpreted as one undergoing longitudinal fission; but there is no one character given, adequate to determine to what family of animalcules it would be referable.

DISOMA *vacillans* consists of two clavate and filiform corpuscles, hyaline, and attenuated at the anterior extremity. Ehrenberg remarks, "Both bodies frequently swam parallel beside each other, and turned on their long axis, moving onwards quickly, though in a vacillating manner; sometimes both bodies gaped widely apart from each other, but never so widely as to form a straight line. 1-380″. On Mount Sinai, Arabia.

Genus TRICHODA.—Body devoid (?) of hairs or cilia: without a constriction or neck; mouth obliquely truncated, destitute of teeth, but provided with vibratile cilia, and a lip. Coloured food is received; the anal orifice is at the posterior extremity. The oblique direction of the mouth gives rise to a very characteristic upper-lip-like projection. In *T. Pyrum* only has self-division been observed. All the species are colourless.

In the system of Dujardin there is both a family Trichodina and a genus *Trichoda*. Speaking of the relations between them and the genus *Trichoda* of Ehrenberg, he observes: "M. Ehrenberg has placed in his family Enchelia a genus *Trichoda*, which in part corresponds with ours; and he has, besides, dispersed among *Leucophrys*, *Enchelys*, *Trachelius*, *Loxodes*, &c., many Infusoria which we have brought together in this family (viz. Trichodina); but, unlike him, we are unable to see their digestive organs."

The Trichodina are soft, variable, flexible animalcules, ciliated, and have either an evident mouth, or one indicated by a varying arrangement of longer cilia. Dujardin would have it understood that this family is only provisional; to comprise a tribe of animals intermediate in organization between the Enchelina—the most simple of ciliated—and the Keronina, which conduct to the highest forms of infusorial life, having defined mouths, and an armature of styles, hooks, &c. The genera included by Dujardin in this family are *Trichoda*, *Trachelius*, *Acineria*, *Pelecida*, and *Dileptus*; the last two having a higher grade of organization. The first-named is thus described:—

Genus *Trichoda* (Duj.).—Ovoid-oblong, or pyriform, rather flexible anteriorly, with a row of cilia directed backwards, and appearing to indicate the presence of a mouth. Their surface does not appear reticulated, or ciliated in rows, as it is in *Acomia* and *Enchelys*. The *Trichoda* are chiefly found in putrid infusions and in stale marsh-water.

TRICHODA *pura* (*Kolpoda Pyrum*, M.). — Oblong, club-shaped, attenuated anteriorly; mouth lateral; vacuoles small. Common in vegetable infusions; usually with *Cyclidium Glaucoma*. 1-720″.

This species closely resembles *Leucophrys pyriformis*, which is somewhat larger and ciliated throughout. However, the reality of *T. pura* as a species is very doubtful,—the small size of the vacuoles, the feature most relied on by Ehrenberg as distinctive, being in reality not at all so, but prone to great variations, determined by surrounding circumstances. It swims slowly, revolving as it proceeds.

T. *Nasamonum.*—Cylindrical, extremities equally obtuse, mouth large, and elongated laterally. 1-288″.

T. *ovata.*—Ovate, turgid, attenuated anteriorly; mouth small and lateral. 1-480″.

T. (?) *Æthiopica.*—Oblong, attenuated posteriorly; under side flat; mouth large. 1-600″.

T. *Asiatica.*—Oval, oblong, cylindrical, rounded at both ends; mouth small. 1-860″.

This species, together with the three immediately preceding, must be regarded as doubtful; for they were merely casually examined by their discoverer whilst travelling, and when, as we must suppose, he had neither the means of comparing the beings with others akin to them, nor very favourable opportunities, in the rough accommodation of desert travelling, for careful microscopic examination.

T. *Pyrum* (*Kolpoda Pyrum*, M.).—Ovate, turgid, acute anteriorly. Amongst Confervæ on Mount Sinai. 1-1200″.

A species with this name is also mentioned by Dujardin as = *Kolpoda Pyrum*? (Müller). It is thus described:—"Body ovoid, oblong, narrowed anteriorly, or pyriform; thicker in one direction than in the other;" and he goes on to say that this is the same being as the *Leucophrys carnium* (Ehr.).

T. *angulata* (Duj.).—Oblong, obliquely and regularly plaited or angular, often with one or more superficial vacuoles. 1-900″.

T. *Lynceus.*—The animalcule described under this name is (says Cienkowsky) probably no other than the young phase of various *Oxytrichæ* and *Stylonychiæ* (Siebold, *Zeitsch.* 1855, vol. vi. p. 301).

Genus LACRYMARIA (XXIV. 274, 275).—Body with a long narrow neck, slightly enlarged near the termination, where is situated the ciliated and lateral (lipped) mouth, destitute of teeth. Body not ciliated. Locomotion is performed by means of the neck, the distensible body, and the oral cilia. The proboscis-like lip is very short, sometimes distinctly articulated, and projects but little beyond the oral orifice. Coloured food is received by *L. Proteus*, and its discharge may be seen to take place from the posterior extremity in one species; in another, green granules (ova) are present.

The genus *Lacrymaria* of Dujardin agrees mainly with that just defined; but the French author differs entirely from Ehrenberg, by stating that the *Lacrymariæ* are distinctly ciliated on their surface, and that the cilia are disposed in regular series among the reticulations of the integument.

Dujardin, in his notes on *Lacrymaria*, has some very just observations on the relation between this genus and the *Phialina* and *Trachelocerca* (Ehr.). He says, the species of *Lacrymaria*, which Ehrenberg noticed to be generally not ciliated on the body, have been classed by him according to the relative position of the mouth and anus,—some among the Enchelia, others, as *Phialina*, among the Trachelia, and others again in the genus *Trachelocerca*, the type of his family Ophryocercina. On this plan, *Lacrymaria* has the body without cilia, prolonged into a narrow neck, terminated by an obliquely truncate and ciliated mouth, at the opposite extremity to which is the anus; *Phialina* similar, except that the neck, instead of being terminated by a simple enlargement, is notched on one side, and the mouth therefore lateral; and *Trachelocerca*, which he himself calls "tailed *Lacymariæ*," have a terminal mouth, and an anus on one side in advance of a conical caudiform prolongation of the body. These distinctions are not borne out by more critical investigations, and at most are insufficient to establish generic characters, and still more those of higher groups or families. As the result of these considerations, Dujardin has comprehended all the species distributed in the three genera named in one, viz. *Lacrymaria*, which he places among the Paramecina.

The doubt expressed concerning the existence of a mouth as described by Ehrenberg, has been removed by later observations.

The variability of form of which the *Lacrymariæ* are capable was noticed by Baker and other old observers, and suggested the appellation *Proteus*, originally bestowed on them. Perty has made use of this peculiarity to constitute a section of Ciliated Protozoa, which he has named "Metabolica." Besides *Lacrymaria*, it includes *Trachelocerca*, those two genera being combined into a family, "Ophryocercina." His genus *Trachelocerca*, however, is not equivalent to the one so named by Ehrenberg, since it also comprises the species of *Phialina* enumerated by that author. This employment of a recognized systematic term with a wider signification than that originally given to it, cannot be commended; and, as Perty makes no attempt to define the differential characters between the two genera as understood by himself, we regard his family Ophryocercina as unsatisfactory. The *Phialinæ* he considers only young or contracted examples of one or other genus. (See PHIALINA and TRACHELOCERCA.)

LACRYMARIA *Proteus* (*Trichoda Proteus*, M.) (XXIV. 274, 275).—Oblong, turgid, with delicate transverse folds. Colour varies from grey to green. The neck is capable of considerable extension. It resembles *Trachelocerca Olor*; but its posterior extremity is rounded, and has at its centre the discharging orifice. Reproductive organs unknown. Amongst Lemnæ. Size stretched out 1-140″.

L. *Gutta*.—Body smooth and nearly spherical, with a very long neck. Perty discovered a tongue-like process above the mouth in some examples. Among Confervæ. Size 1-1150″; including neck, 1-210″.

L. *rugosa*. — Nearly globular, and wrinkled; the neck of medium length; granules green. In swimming, it often revolves on its long axis; neither cilia nor an enlargement is observable near the mouth. 1-570″; including neck, 1-288″.

L. *versatilis* (Duj.) (*Trichoda versatilis*, M.).—Fusiform; neck retractile, ciliated beneath, shorter than in *L. Proteus*, which it is further unlike by having the body pointed posteriorly, and by living in sea-water.

Perty declares this is not an independent species, but only the immature form of *Trachelocerca Olor* (Ehr.).

L. *tornatilis*.—Neck retractile, sometimes disappearing entirely, presenting then only the cilia crowning its extremity.

L. *farcta*.—Flask-shaped, with a short neck. In ditch-water about Paris. 1-260″.

Genus LEUCOPHRYS (XXIV. 276, 277, 278, 279, 280).—Covered with vibratile cilia; mouth oblique, terminal, without teeth. From the obliquity of the mouth, there is the appearance of an upper lip. The cilia which cover the body are short and disposed in rows; those around the mouth are longer, and produce very powerful currents. In swimming, all the species revolve upon the longer axis. A serpentine alimentary canal, with more than fifty grape-like stomach-cells (XXIV. 276), terminating at the opposite extremity to the mouth, is described by Ehrenberg; in some, one or two globular nuclei and a contractile vesicle are seen. Self-division transverse and longitudinal.

Leucophrys forms, in the system of Dujardin, with *Spathidium* and *Opalina*, the family "Leucophryens," characterized by having "an oval or oblong depressed body, covered with cilia densely but regularly disposed; mouth not evident; foreign solid particles are not to be found in the vacuoles; hence probably these animals live only by absorption. Most of them are parasitic within Annelida and Batrachia, and soon perish in pure water, like Helminthoid (tape) worms." Dujardin says, "It is to the genus *Bursaria* that Ehrenberg has transferred most of the true Leucophryens, in conjunction with other Infusoria having a very distinct mouth." (See OPALINÆA, p. 569.)

Dujardin's characters of *Leucophrys* are :—" Body depressed, oval or oblong, equally rounded at the two ends, covered by long, very numerous, vibratile cilia, in parallel rows; no mouth. I," says Dujardin, "have restricted the term to animalcules parasitic within *Lumbrici*, but ought probably to include the form met with by Ehrenberg in the *Anodontæ*."

This genus requires further examination, and may probably be cancelled by the transfer of its members to other groups. It is certain that several of its enumerated species are mouthless, and that some belong to the Opalinæa; and Dujardin clearly pursued a very right course in detaching it from the heterogeneous class Enchelia, and in bringing it into relation with *Opalina*. Perty has followed a similar plan, and instituted a family of parasitic animalcules under the name of Cobalina, comprehending besides *Leucophrys* (represented by only one species, *L. striata*) *Opalina*, *Plagiotoma*, and *Alastor*. Like Dujardin, also, he transfers *L. patula* to *Bursaria*; treats *L. Spathula* as identical with *Spathidium hyalinum* (Duj.), but places it in a family Holophryina, along with *Holophrya* and *Enchelys* (*i. e.* as represented by *E. Farcimen* and *E. Pupa*). Neither Ehrenberg's descriptions nor figures are sufficient to identify *L. sanguinea* either with *Bursaria* or *Opalina*; its colour lends no aid, since it is doubtless accidental. *L. pyriformis* and *L. carnium* are doubtful members, and the rest named are petty clearly Opalinæa. *L. carnium* is treated by Dujardin as identical with *Trichoda carnium*.

LEUCOPHRYS *patula* (*Trichoda patula*, M.) (XXIV. 276, 277) (*Bursaria patula*, Duj.). — Oval, campanulate, turgid; sometimes quite pellucid, at others whitish; mouth ample and gaping; vacuoles are very large, and fill themselves with food in an irregular manner. When (says Ehrenberg) the animalcule is quiet, the passage of the food onwards is seen in the serpentine canal, to which the stomachs are attached like berries; even the stalk or short communicating tube is visible when they receive or discharge coloured food. The longitudinal rows of cilia are very numerous in full-grown specimens. The granules are white by incident light, brownish by transmitted. In the middle of the body is a small globular nucleus. Both in fresh- and sea-water. 1-280" to 1-96".

L. *Spathula* (= *Enchelys Spathula*, M.) (XXIV. 278). — Lanceolate, compressed, whitish; mouth narrow, situated at its anterior extremity, which is obliquely truncated and membrane-like. Amongst Lemnæ. 1-140". Vide SPATHIDIUM *hyalinum*, p. 612.

L. *sanguinea* (*Trichoda striata*, M.) (XXIV. 279, 280).—Cylindrical, rounded at both extremities, and of the colour of blood. Ehrenberg remarked within it two bright contractile round bladders, and that on self-division one was present in each part. 1-144".

L. *pyriformis* (*Kolpoda Pyrum*, M.).—Ovate, whitish, rather more acute anteriorly; vacuoles large. 1-570" to 1-280".

Dujardin considers that this species should rightly be transferred to *Glaucoma* or *Kolpoda*.

L. *carnium* (*Kolpoda Pyrum*, M.).—Oval, oblong, acute anteriorly, and of a whitish colour; vacuoles narrow. In putrescent animal water, and the drainage of manure. 1-1440" to 1-430". It = *Trichoda Pyrum* (Perty).

Perty suggests that *Enchelys nodulosa* is referable also to this species.

L. (?) *Anodontæ* (*Leucophra fluida*, M.). — Oval, turgid, and transparent; rounded at both extremities. In Siberia and at Copenhagen. 1-430". Most probably it is an *Opalina*.

L. *striata* (Duj.).—Oblong, marked by thirty-five longitudinal granular striæ. 1-325" to 1-200". In the *Lumbrici* (worms) of gardens.

This is the only species of *Leucophrys* retained by Perty. On the other hand, Stein (p. 184) asserts that it is an *Opalina*, a mouthless animalcule, and therefore rightly excluded from Enchelia.

L. *nodulata* (Duj.).—Oblong, regularly ciliated; without distinct striæ, but having two series of vacuoles. In *Lumbrici*.

The last three supposed species are, says Stein (*Infus.* p. 184), *Opalinæ*, and the last two should be united as one, which may be named *O. Lumbrici*. (See family OPALINÆA, p. 569.)

Genus SPATHIDIUM (Duj.) (XXVI. 27).—Oblong; thicker and more rounded behind; thinner, expanded, and truncated in front.

This genus is admitted by Perty, who places it in the family "Holophryina," but, unlike Dujardin, believes it to possess a mouth.

SPATHIDIUM *hyalinum* (XXVI. 27). — Oblong, lanceolate, hyaline; thin and almost membranous anteriorly, and terminated by an oblique margin, along which some small black nodules may be seen. In pond-water, near Paris. The *Enchelys Spathula* of Müller would seem to be the same species; but the *Leucophrys Spathula* (Ehr.) differs from it in having a row of cilia on the anterior margin, with striæ on each side, and in receiving indigo in its stomach-sacs.

Perty, however, treats them as identical. Indeed, the marks of distinction Dujardin would draw are certainly insufficient to establish a specific difference; since the absence or presence of a row of cilia may readily be unobserved, and the reception or non-reception of indigo is very much a matter of manipulation.

Genus HOLOPHRYA (XXIV. 281).—Ovoid, oblong, or even cylindrical; covered with vibratile cilia; mouth anterior, directly truncated or terminal, and without lip or teeth. In two species the mouth and anus have been seen. Cilia disposed in longitudinal rows. In *H. Ovum* green granules and a posterior contractile vesicle are observable; self-division appears to be transverse in *H. discolor*.

In the system of Perty, *Holophrya* gives name to a family "Holophryina," defined as having "an anterior mouth, a posterior anus, and the surface covered with cilia in longitudinal rows." It includes the genera *Holophrya*, some species of *Enchelys* and *Spathidium* (Duj.), *Leucophrys* (E.). The two species of *Enchelys* mentioned are *E. Farcimen* and *E. Pupa*; the *Leucophrys* is the *L. Spathula* (Ehr.).

Holophrya is closely allied to *Prorodon*; indeed its independence is very doubtful; for the only distinctive character between the two genera put forward is, that the "dental cylinder" is absent in the former; but this is a structural peculiarity not always very obvious to the eye, liable to be overlooked, and of secondary histological importance.

Holophrya and the following genus, *Prorodon*, are included in Dujardin's family Paramecina.

HOLOPHRYA *Ovum* (*Leucophra bursata*, M.) (XXIV. 281). — Ovate, somewhat cylindrical, extremities subtruncate; granules green. Amongst Lemnæ and Confervæ. 1-570" to 1-210".

H. *discolor* (*Trichoda horrida*, M.).— White, ovate, conical, subacute at the posterior extremity; cilia long and scattered. Amongst Confervæ. 1-240".

This species Stein has noticed in the encysted condition, surrounded by a thick-walled cyst. Cohn, moreover, found the previous species, *H. Ovum*, in the same condition. Instead of being white, it is often coloured green by chlorophyll.

H. *Coleps* (*Leucophra globulifera*, M.). —Oblong, cylindrical; rounded at both extremities; whitish. 1-430" to 1-280".

H. *brunnea* (Duj.).—Brown, changing from a cylindrical to a globular form when filled with food, and also then altering in colour.

Genus PRORODON (XXIV. 282; XXVIII. 8).—Is distinguished by the directly truncated mouth, and a circlet or cylinder of internal teeth. Body covered with vibratile cilia. Digestive cells, an oral, and an anal outlet have been demonstrated by coloured food. A long band-like nucleus, contractile sac, and granules are seen in *P. niveus*.

In the system of Perty, *Prorodon* constitutes a member of the family Decteria, in company with *Chilodon, Nassula, Habrodon*, and *Cyclogramma*. *Habrodon* is annexed to this present family; but *Cyclogramma* will be found placed among the Trachelina, along with *Chilodon* and *Nassula*.

PRORODON *niveus*.—Large, elliptical, and compressed; colour white; circlet of teeth compressed (*teste* Ehr.), as shown separate in XXIV. 283. Smaller examples have fewer teeth than the large. Cilia very fine. It is found encysted. Amongst Confervæ in turf-pools. 1-72″. Cohn intimates (*Zeitschr.* 1853, iv. p. 271) that this species and the next are merely varieties of the same being.

P. *teres* (XXIV. 282; XXVIII. 8).—Ovate, cylindrical, white; circlet of teeth cylindrical. Ehrenberg counted twenty supposed teeth; and when the cylinder was broken, forty-five. Revolves, in swimming, upon the long axis. 1-140″. It has been seen in the encysted state, and to undergo fission when in that condition.

P. *viridis*.—Large, elliptic, compressed, green, with a nearly cylindrical crown of teeth. 1-120″. Berlin.

In all probability this green-coloured organism is a mere variety of the preceding, from which it offers no distinctive features. In *Prorodon*, as in *Chilodon*, fission occurs in encysted beings.

P. *vorax* (Perty).—Hyaline, seldom green; dental apparatus faintly marked. Integument covered with wart-like elevations in rings. Movements tolerably rapid; oftentimes oscillating. Anus placed at posterior extremity. 1-240″ to 1-84″. It chiefly differs from *P. niveus* by its faintly-marked dental apparatus.

We have yet to append some genera (whose affinity is with the foregoing) described by Dujardin, viz. *Acomia*, *Gastrochæta*, *Alyscum*, and *Uronema*,—and which, with the genus *Enchelys*, constitute his family Enchélyens (Enchelina).

Acomia and *Gastrochæta* are only ciliated partially—the former at one end, the latter along a longitudinal furrow on the under surface. *Enchelys*, *Alyscum*, and *Uronema* are ciliated throughout,—the first having but one form of cilia; the second, cilia together with some long, contractile, trailing filaments; and the last, cilia with a single, straight and long posterior filament.

Genus ACOMIA (D.) (XXVI. 16, 17).—Oval or irregular, oblong, colourless or cloudy, formed of a homogeneous glutinous substance containing unequal-sized granules, and ciliated at one end. No mouth.

Perty remarks that there is an absence of definite characters between this genus and the *Enchelys* (Duj.), and that the species of *Acomia* require further study.

ACOMIA *Cyclidium* (XXVI. 16 *a*, *b*).—Oval, oblong, depressed, containing large granules and some vacuoles; transverse fission. In external form approaches *Cylidium* (Ehr.). Marine. 1-650″.

A. *vitrea* (XXVI. 17 *a*, *b*).—Ovoid, hyaline, but rendered cloudy by granules in its posterior half; anterior border ciliated; division longitudinal. 1-1250″. In fetid water.

A. *ovalis*.—Differs from the preceding by the granules occupying the *anterior* half, and by its length, 1-868″. In fetid marsh-water.

The difference in position of the granules is valueless as a specific distinction between this and the previous species, and should be rejected.

A. *Ovulum*.—Ovoid, presenting a nodular or granular portion, which seems to contract itself within the interior of a diaphanous envelope. Revolves in moving, like a *Doxococcus*. 1-300″.

Stein (*Infus.* p. 137) declares that it is undistinguishable from *Cyclidium Glaucoma* (Ehr.).

A. (?) *Vorticella*.—Ovoid, nearly globular, colourless, cloudy; ciliated in its anterior half; cilia curved backwards. Revolves on its axis in progressing forwards. 1-1000″. In sea-water.

A. (?) *costata*. — Ovoid-oblong, narrower in front; apparently enclosed by a thick membrane, or consistent layer; nodular; nodules often arranged in rows as ribs. Division transverse. 1-650″ to 1-500″. In sea-water, among Algæ.

A. *varians*. — Oblong, cylindrical; truncated and angular in front; dilated and compressed, by turns, in different parts of its length, and consequently alternately rounded and constricted behind, so as to terminate by a pointed tail. Revolves on its axis. 1-1000″ to 1-450″.

A. *inflata*.—Oval, tapering anteriorly, beset everywhere with very fine cilia; colourless, or occupied with green, grey, or brown granules. Movement rapid.

revolving. Cilia often appear longer in front. Found by Dujardin and Perty in decomposing marsh-water.

A. *cava* (Perty).—Oval, slightly irregular; convex above, flat beneath, or rather concave. Thickly ciliated all over. 1-670″. Amongst Lemnæ.

Genus HABRODON (Perty).—Body subcylindrical, rather bent; thickened posteriorly, and mostly truncate in front. Mouth anterior, with a very delicate dental apparatus. Anus posterior. Cilia in longitudinal rows.

This genus, created by Perty, is placed by him in juxtaposition with *Prorodon*, with which and *Chilodon*, *Nassula*, and a new genus, *Cyclogramma*, it constitutes a family called Decteria.

HABRODON *curvatus* = *Enchelys Pupa* (?) (Müll.).—Colour usually grey or pale green, with numerous molecules and vesicles; anteriorly it is hyaline, and posteriorly it presents a round clear space (an anus?). Movements slow. 1-390″ to 1-132″. In springs, with *Chara*, &c., Bern.

Genus ACROPISTHIUM (Perty) (XXVIII. 61).—Circular, with an anterior flap, or rounded off; pointed behind.

ACROPISTHIUM *mutabile*. — Hyaline, with darker vesicles and molecules. Movements very rapid, revolving. Cilia cover the entire surface, very fine, usually more perceptible anteriorly. The figure varies much. Mouth in front (?). 1-360″ to 1-320″. Uncommon.

Genus BÆONIDIUM (Perty) (XXVIII. 52–54).—Small, subcylindrical; cilia at anterior end large; movement sluggish.

BÆONIDIUM *remigans*.—Usually prismatic and rounded; often rather wrinkled; hyaline, but nearly always filled with green corpuscles. Cilia generally distributed; the large anterior ones simulate pedal organs in their movement. A slight depression sometimes perceptible on one side, in the position of the mouth. Fission transverse. 1-840″ to 1-660″. Amongst Charæ, but rare, in Switzerland.

Genus OPISTHIOTRICHA (Perty) (XXVIII. 55–57).—Small, elongated-cylindrical or pyriform; cilia distributed over the body, very fine, some of those on the posterior extremity large, ciliary action sluggish.

OPISTHIOTRICHA *tenuis* (XXVIII. 55–57).—Colourless or slightly green, with delicate vesicles and molecules in the interior. Swims very rapidly, revolving at the same time on its long axis. Large posterior cilia from two to three in young specimens, five to six in old. 1-900″ to 1-440″. In marsh- or bog-water. Bern, &c.

Genus SIAGONTHERIUM (Perty) (XXVIII. 62, 63).—Very small, extended anteriorly, thickened posteriorly; with a long stiff bristle extended backwards on one side of the anterior extremity.

SIAGONTHERIUM *tenue*.—Seen on the wider side, elongated ovate; anterior prolongation directed forwards from the smaller subcylindrical half. Extremely delicate, with internal molecules and vesicles. Scarce in pools. Bern, with *Hysginum pluviale*. 1-900″ to 1-760″.

Genus MEGATRICHA (Perty) (XXVIII. 58–60).—Very small, clothed with long, scattered and slowly-moving cilia. Body entire, or divided incompletely into two unequal portions. "These are the most delicate and simple of all the Ciliata."

MEGATRICHA *integra*. — Undivided, colourless, with long, delicate cilia. Very possibly *Chætomonas Globulus* belongs to this species. 1-1440″. Uncommon.

M. *partita* (XXVIII. 58–60).—Divided

into a smaller, rather pointed, anterior section, and a wider posterior one; colourless. Extremely delicate; often composed, like many Monads, of only five molecules. Movements of cilia sluggish. Swimming often interrupted suddenly by a jerk in another direction. Fission longitudinal. 1-1560″ to 1-1320″. Rare, among decomposing Confervæ.

Genus PTYXIDIUM (Perty) (XXVIII. 40–42).—Ovate, pointed in front, with several folds. Cilia equal, very fine.

PTYXIDIUM *Ovulum*=*Leucophrys pyriformis* (Ehr.). *Kolpoda Pyrum* (Müll.), which Ehrenberg cites as synonymous, is more probably an *Acomia*. Perty discovered no food in the interior.

Genus COLOBIDIUM (Perty) (XXVIII. 45).—When mature, ovate; in earlier condition, truncate posteriorly—frequently emarginate,—rounded anteriorly. Cilia in longitudinal rows, those in front longer; their movements slow.

COLOBIDIUM *pellucidum*.—Very transparent, colourless or clear green; movements rapid, always rotating. "The longer cilia in front often moved in a foot-like manner." 1-1900″ to 1-600″. In turf-hollows among Confervæ. Bern. *Acomia Vorticella* (Duj.) is probably only a variety of this species.

Genus APIONIDIUM (Perty) (XXVIII. 48, 49).—Rounded; thicker in front than behind; rows of cilia few in number.

APIONIDIUM *modestum*. — Hyaline, with coloured (green or brown) food-particles. Rows of cilia from seven to nine; cilia very fine. A round clear space usually visible posteriorly. Rare. 1-260″ to 1-240″.

Genus GASTROCHÆTA (Duj.) (XXVI. 18).—Body oval, convex on one side, and hollowed by a longitudinal furrow on the other; cilia seated in the furrow, chiefly at the two ends.

GASTROCHÆTA *fissa* (XXVI. 18). — Semitransparent, oval, truncate in front. 1-408″. In the water of the Seine.

Genus ALYSCUM (Duj.) (XXVI. 20). — Body ovoid-oblong irregular, surrounded by radiating cilia, and having, besides, a lateral bundle of long retractile cilia, by means of which it leaps briskly from place to place.

The single species much resembles *Enchelys nodulosa* (*Paramecium Milium*, or *Pantotrichum Enchelys*, Ehr.) from which it is distinguished by its retractile filaments.

ALYSCUM *saltans* (XXVI. 20).—Colourless, oblong, rounded at the ends, rather concave along the side bearing the retractile filaments, and marked by some almost invisible longitudinal furrows. 1-1300″ to 1130″. In infusions and in the Seine.

Genus URONEMA (Duj.) (XXVI. 25).—Body long, narrower in front, rather curved; surrounded by radiating cilia, and bearing a long straight cilium behind.

URONEMA *marina* (XXVI. 25).—Colourless, semi-transparent, nodular, elongated; contracted in front; slightly curved, with from four to five slightly-marked longitudinal striæ. 1-595″. In the Mediterranean.

Stein considers this form, as in the instance of *Cyclidium Glaucoma*, to be merely an embryo of an Infusorium, and not an independent species.

FAMILY VI.—COLEPINA.

(XXIV. 284, 285).

Loricated animalcules having the mouth and anus placed at the opposite extremities of the body. The lorica is of the form of a small cask, composed either of minute plates placed in a row, or of little rings between which cilia are situated; anteriorly it is truncated, smooth or toothed, and posteriorly terminated by three to five little points; mouth ciliated. The digestive vacuoles in these creatures are readily filled with coloured food, which is ejected posteriorly. Complete transverse self-division has been observed. A distinguishing character of the Ciliated Protozoa is their asymmetrical figure; but the genus *Coleps* is an exception to the general rule.

In the act of fission a new formation of tissue appears to take place along the future line of separation, thinner and softer in consistence than the original covering.

Genus COLEPS (XXIV. 284–286).—This being the only genus, its characteristics are identical with those of its family.

COLEPS *hirtus* (*Cercaria hirta*, M.) (XXIV. 284–286).—Body white, oval, with truncated ends; lorica apparently composed of small polygonal plates, between which the cilia are both transversely and longitudinally arranged. Anteriorly there are nineteen pointed processes, and posteriorly three. Movements very brisk; so that it is difficult to examine the lorica while the animal is living; but when it is dried, or pressed between glasses, the complex structure of the former is rendered visible. Amongst Confervæ. 1-570″ to 1-430.″

Although described by Ehrenberg as colourless or white, this is no specific character; for it may frequently be coloured green by chlorophyll, or tinted with intermediate shades between yellow, green, and brown, according to the food taken and its changes by digestion.

C. *viridis*.—Green, oval, and ciliated; lorica terminating in three points. Amongst Confervæ. 1-960″ to 1-570″.

Except in the matter of colour, no distinction from the preceding is noted; its specific independence may therefore be fairly questioned.

C. *elongatus*.—Cylindrical, elongated; lorica white, and terminating in three points; self-division transverse. 1-570″ to 1-430″.

Between this form and *C. hirtus* Perty has seen every intermediate figure, and therefore regards it as a mere variety, and not a species. The colour, it hardly needs be stated, is in no way characteristic.

C. *amphacanthus*.—Ovate, shorter. Lorica, unlike that of the other species, composed of rings; the anterior part crowned with unequal teeth, the posterior having three strong spines. Found in *Spirostomum virens*. 1-280″.

C. *incurvus*.—Oblong, nearly cylindrical, and slightly curved; lorica terminating in five points. Amongst Confervæ. 1-430″.

C. *inermis* (Perty).—Lorica costate, not granular; no spinous points at posterior end, or very feeble ones. Green corpuscles occur internally. The distinctness of the ribs varies, as well as the length and thickness of the body. Motions like those of *C. hirtus*. 1-600″. Fresh water.

FAMILY VII.—TRACHELINA.

(XXIV., XXVIII., XXIX.)

This extensive family includes those animalcules which have two distinct alimentary orifices—the receiving one lateral, the discharging one terminal. They have no lorica; but all the genera, except *Phialina*, are covered with vibrating cilia, generally disposed in longitudinal rows, those near the mouth being the longest. *Trachelius* has no neck; but the frontal portion of the body is prolonged in the form of a long trunk-like lip; in *Loxodes* and *Chilodon* it is like a hatchet-shaped broad lip. In *Glaucoma* there is a tremulous flap to the mouth, and in *Chilodon* and *Nassula* a cylinder of rod-like teeth, which sometimes projects in advance of the mouth. *Bursaria* and *Nassula* have a thick frontal protuberance. The reception and discharge of coloured matter can be seen in all the genera. In *Nassula* the violet-coloured specks (bile) are worthy of notice. In *Spirostomum* the mouth is spiral. A nucleus and one or more contractile vesicles occur in all the genera. Complete transverse and longitudinal self-division is frequent and complete.

The genera are disposed as follows:—

Teeth absent.	No tremulous mouth-flap.	Brow continuous with the body.	Mouth simple	with a brow-like upper lip	lip long, proboscis-like......	Trachelius.
					lip broad, hatchet-shaped...	Loxodes.
				brow-like prominent back		Bursaria.
			Mouth spiral			Spirostomum.
		Brow interrupted in a peg-like manner.......................				Phialina.
	Mouth having a tremulous flap					Glaucoma.
Teeth present	A brow-like prominent upper lip					Chilodon.
	A brow-like prominent back					Nassula.

This family is not recognized by Dujardin, who rejects the supposed affinities of its genera as unnatural; and indeed it must be owned that the Trachelina, as understood by Ehrenberg, represent a heterogeneous collection rather than a natural group. *Bursaria* includes some mouthless *Opalinæ*. *Spirostomum* evidently takes its place next to *Stentor*; and *Chilodon* and *Nassula* are removed in several important details of organization from *Trachelius* and *Phialina*.

Perty retains in his classification a family Trachelina, and places in it the genera *Trachelius, Harmodirus, Amphileptus, Loxophyllum, Dileptus, Pelecida,* and *Loxodes,*—adopting, however, the characters assigned by Dujardin in preference to those given by Ehrenberg. The brief character of Trachelina recorded is—“Body elongated anteriorly into a neck-like process, or protruding a proboscis curved on one side.”

We have retained in the preceding description of Trachelina, adopted from Ehrenberg, several notes of structural peculiarities which subsequent researches show to be erroneous. That the mouth is lateral and the anus terminal in all the members of the family is not the case. Thus, in *Chilodon* the discharging orifice is on one side, near the posterior extremity. Lachmann (*A. N. H.* 1857, xix. p. 216) speaks of the buccal orifice of *Glaucoma* as produced into two flaps. The teeth (so called) in *Nassula, Chilodon,* &c., have no real claim to that designation; for they are no more than folds or thickenings of the œsophagus (see Part I. p. 311). The violet-coloured spots, imagined by Ehrenberg to be vesicles, are merely accidental specks of colour derived from the food (see p. 312, and notes on Nassula *elegans*).

Chilodon and *Nassula* have been proved to propagate by living embryos, after a previous encysting-stage; and in all probability most of the other genera do so likewise. *Nassula ambigua* (Stein) has been seen in the same encysted condition as *Chilodon*; and only the last stage, that of the internal development of a ciliated embryo, to complete the cycle as in *Chilodon*, has escaped observation.

Genus TRACHELIUS (XXIV. 287-290).—Body ciliated; mouth simple, destitute of teeth, is seated on one side at the base of the very much elongated upper lip or proboscis. Cilia are absent in three species. In four species coloured food has been received, and in three the discharging orifice detected. It has also a collapsed œsophagus, visible only during the passage of food. Two species increase by transverse self-division.

This genus forms a member of the family "Trichodiens" (Trichodina) (Duj.), along with *Trichoda* and genera named *Acineria, Pelecida,* and *Dileptus.*

The account he gives of the animals differs much from the foregoing. According to it, *Trachelius* is destitute of a contractile or reticulated integument, and is composed of a muco-gelatinous substance (sarcode) containing granules, which are oftentimes agglomerated in the form of nodules, disposed in rows. The apparent oviposition in *T. Ovum* and *T. Meleagris* was nothing more than the breaking up of part of the animalcule by "diffluence," and the supposed ova only particles of "sarcode."

"The cilia at the anterior extremity are larger than those on the rest of the body. Posteriorly a large vacuole is often to be seen. There is no distinct mouth."

The last statement is contradicted by recent investigations, which prove that the animalcules belonging to this family have a mouth, and some of them, at least, an anus.

Trachelius *Anas* (*Trichoda Anas* et *Index*, M.)(xxiv. 287-289).—White, clavate, and cylindrical; proboscis thick, obtuse, not half the length of body; mouth situated close to the base of the proboscis. In exposed infusions, and freshwater swamps, amongst Confervæ. The interior often contains green (chlorophyll) vesicles. 1-280″ to 1-120″.

T. *vorax.*—Clavate-ovate, turgid, colour white; proboscis thick, obtuse, shorter than half the body; mouth situated near the middle of the body, and not at the base of the proboscis. Amongst Confervæ. 1-120″.

T. *Meleagris.*—Compressed, lanceolate, often curved in the form of the letter S; proboscis thick, obtuse, shorter than half the body. 1-96″ to 1-60″.

Ehrenberg described in this species a red-coloured fluid which he called bile, and a row of ten to twelve vesicles along the back, which he concluded to be stomach-cells filled with red gastric juice. It is now, however, admitted that these cells are really contractile, and form a vascular chain. The nucleus is oval, with a central constriction. Dujardin adopted this species as one form of a new genus, *Loxophyllum*, hereafter described in the family Colpodea.

T. *Lamella* (*Kolpoda Lamella*, M.) (xxvi. 24 *a, b*).—Depressed, laminar, elongated, linear-lanceolate, often truncated anteriorly and rounded; margin ciliated (Dujardin says, only in front). Ehrenberg considers this form may be no other than the young condition of *Amphileptus Fasciola*; and Perty would add, of *Spathidium hyalinum.* In sea-water. 1-900″ to 1-200″.

T. *Anaticula.*—White, small, ovate, pyriform, attenuated and diaphanous anteriorly. Dujardin believes he has seen several of these animalcules become by simple contact agglutinated together,—a circumstance which would indicate the absence of a true integument. Amongst Confervæ. 1-570″ to 1-280″.

T. (?) *trichophorus* (*Vibrio strictus*, M.)—Cylindrical, changeable, often clavate; proboscis capitate, of the form of a very delicate whip. 1-1200″ to 1-430″.

T. (?) *globulifer.*—Spherical, hyaline, with a very delicate whip-like acute proboscis. Amongst Confervæ. 1-200″.

T. *Ovum* (xxiv. 290).—Large, ovate, wide or campanulate anteriorly; proboscis short, in the form of a beak; contractile vesicles numerous. "In no infusorial animalcule," says Ehrenberg, "is the alimentary canal so easily seen as in this; the large mouth and contractile vesicle, lying over the lower part of the alimentary canal, are equally evident; numerous small digestive cells and ova-granules appear in every part." It is in this species that Lieberkühn and Lachmann have latterly described the existence of an arborescent, ramified digestive canal, quite distinct from the clear round spaces in the parenchyma of the body, which some have supposed to be stomachs. In stagnant bog-water. 1-72.″ It has been found encysted. (Vide Part I. p. 309).

T. (?) *laticeps*.—Flattened, elliptical; anterior part (head) membranous, variable and wide, with a notch from which proceeds a flagelliform proboscis almost double the length of the body. 1-912″. In North Sea.

T. *dendrophilus*. — Ovate, subacute. at each end; proboscis very fine, acute, double the length of the body. 1-288‴; with filament, 1-96‴ to 1-72‴. Has the habit of a Monad, but the motion of *T. trichophorus*, than which it is very much smaller. On tree-mosses.

T. *strictus* (Duj.).—Filiform, extremities rather pointed; the cilia visible only in front. 1-400″. Amongst Lemnæ; seen also by Perty in Switzerland.

T. *teres*.—Filiform, cylindrical, obtuse anteriorly, pointed and tapering behind; ciliated only in the anterior margin. 1-170″. In stagnant sea-water.

T. *Falx*.—Long, depressed, lanceolate or sigmoid; variable; narrower and rather curved anteriorly in a sickle-like form; ciliated generally. 1-420″. In pond-water.

T. *noduliferus* (Perty).—Very slender, narrowed anteriorly, but terminated abruptly by a rounded end; colourless, but with diffused chlorophyll-vesicles at times, and granules. Cilia scarcely visible, except near the head, where they are rather larger. Movements slow. The elongated neck-like portion devoid of molecules. 1-570″ to 1-120″ (Bern).

T. *apiculatus*. — Slender, tapering anteriorly, its end being obtuse. Colourless, with diffused vesicles and molecules. Cilia very delicate. Movements rapid, like those of *Tracheloccrca*. 1-144″.

T. *pusillus*.—Considerably elongated; rather flattened; colourless; with a round opening at its narrower anterior extremity. Movements tolerably quick, with slow revolutions on its axis.

Perty intimates it to be the same species as *Trachelius trichophorus* (Ehr.) and the *Peranema protractum* (Duj.).

Genus LOXODES (XXIV. 291–293).—Body ciliated throughout, mouth simple, devoid of teeth; upper lip continuous and broad, hatchet-shaped; locomotive cilia longer near the mouth. The contractile vesicle is round; the nucleus oval or ovoid. In *L. Bursaria* an oval nucleus and two contractile globular vesicles have been seen. Self-division transverse.

Dujardin's characters of *Loxodes* are—“ Body flat, membranous, or with an apparently membranous lorica, flexible but not contractile, expanded at the centre of its superior or dorsal surface, often concave on the under surface; contour irregularly oval, sinuous and obliquely prolonged anteriorly; furnished with very fine cilia, confined to its anterior margin. In general characters,” he adds, “ *Loxodes* approaches nearest to *Trachelius* (family Trichodina); but the signs of an integument are so clear as to sever it from that genus and family.” The *Loxodes* described by the French author are almost all of them distributed by Ehrenberg among other genera and families; and hence there is unfortunately none but the slightest relation between the similarly-named genus of the two writers. Thus the *Loxodes Rostrum* of Ehrenberg is the representative of a genus *Pelecida*, of the family Trichodina, in the system of Dujardin, and bears the name of *Pelecida Rostrum*. In this position it is brought into close relation with the genera *Trichoda* and *Trachelius* (Ehr.), and with two others, named by Dujardin *Acineria* and *Dileptus*.

The last-mentioned genus comprises Infusoria placed by Ehrenberg with *Amphileptus*, in describing which we shall take the opportunity to give the characters of *Dileptus*, whilst *Acineria* and *Pelecida* will be included among the appended genera at the end of the present family, Trachelina.

LOXODES *Rostrum* (*Kolpoda Rostrum*, M., *Pelecida Rostrum*, D.) (XXIV. 291–293).—Body compressed, white, lanceolate, slightly curved in the form of an S, in consequence of the lip being a little uncinated. Ehrenberg states that he has very often seen large *Naviculæ* and *Synedræ* within this creature, although it would not feed on coloured food. The cilia are very delicate. (XXIV. 291, an animalcule which has fed upon Bacillaria; XXIV. 292, another, creeping along

Confervæ; and xxv. 293, a specimen undergoing transverse self-division.) Amongst Confervæ. 1-144" to 1-36".

L. *Cithara* (*Trichoda aurantia*, M.).—Triangular and compressed; anteriorly dilated and obliquely truncated, but pointed at the posterior extremity. Colour white. 1-430" to 1-210".

L. *Bursaria.*—Oblong; anteriorly obliquely truncated and depressed; posteriorly hemispherical. The mouth is placed near the centre of the ventral surface, at the bottom of a deep funnel-like fossa (vestibulum), the upper border of which is longer, broader, rather concave, and truncate, and constitutes the "upper lip" of Ehrenberg. A long œsophagus extends far into the interior from the mouth. In bogs. 1-280".

This, Focke and Stein show, is not a species of *Loxodes*, but of *Paramecium*, and therefore rightly named *P. Bursaria* (which see, p. 635). It was this species which was so elaborately examined by Cohn, especially with regard to its reproduction. Young specimens are colourless; but mature beings have numerous chlorophyll-corpuscles diffused in their cortical laminæ. There are two round contractile spaces, which by pressure assume a stellate appearance similar to those of *P. Aurelia*. The rotation of the contents may be demonstrated in this species; and Cohn, Focke, and Stein have witnessed its reproduction by a living germ or embryo. In figure it is very like *Chilodon Cucullulus*, but has the oral fossa (vestibule) and cilia of *Paramecium*.

L. *plicatus.* — Elliptical, depressed, convex on the back, and slightly plicated; the lip uncinate. On Confervæ. 1-430".

The species of *Loxodes* mentioned by Dujardin are *L. Cucullulus* = *Chilodon Cucullus* (Ehr.); and *L. Cucullio* = (?) *Kolpoda Cucullio* (M.), placed by Ehrenberg among the Kolpodea.

L. *reticulatus.* — Oval; more slender, sinuous, and flexible anteriorly; surface granular. In long-kept marsh-water.

This species is, in Stein's opinion, a mere accidental variety of *Chilodon Cucullulus*, determined by the bulk of food received.

L. *marinus.*—Depressed, oval, almost reniform; with internal fine granules, and a row of puncta near both the anterior and posterior margins. 1-350". In salt water.

L. *dentatus.*—Similar to *L. Cucullulus*, but having a bundle of bristles about the mouth, as in *Chilodon*, from which it differs by the lorica (cuirass) and by the absence of cilia on the surface.

The distinction of this species and *L. Cucullulus* as independent, Stein rightly criticizes as an error on the part of Dujardin, and shows (*Infus.* p. 131) that both of them are only accidental varieties of *Chilodon Cucullulus,*—*Loxodes Cucullulus* being nothing more than small specimens in which the œsophagus is indistict, and *L. dentatus* examples in which this organ is very evident.

L. *brevis* (Perty). — Short, rounded, with a hyaline proboscis. 1-500". Bern, in rainwater-ponds.

Genus BURSARIA (XXIV. 294–296).—Surface ciliated throughout; anterior part convex; mouth not terminal, fringed with stronger cilia, though simple, toothless, and devoid of tremulous flap. The cilia are distinctly seen in coloured water, and are generally disposed in rows; those around the mouth are longer than the others. The nutritive system (says Ehrenberg) consists of an alimentary canal, curved forwards; it is furnished with digestive cells resembling little purses, which are attached to it by short stalks. The mouth is large, situated, as in *Leucophrys*, obliquely at the anterior extremity, so that a brow, as it were, either projects over it or else forms the end. The contractile vesicle is sometimes doubled; the nucleus oval or ovoid. The anus is placed at the posterior extremity. Self-division, longitudinal or transverse, has been observed in five species.

Dujardin has the following remarks on this genus:—"Ehrenberg, whilst admitting a genus *Bursaria*, separates from it several true species, and places some of them in his genus *Leucophrys*, others in his family Kolpodea; whilst the closely allied genera *Kondylostoma* and *Plagiotoma* are confounded with other families—the former with *Oxytricha*, the latter with *Paramecium*. Moreover, the obliquity of the mouth in *Bursaria* is not a sufficient distinction between that genus and *Leucophrys*; and, whilst assigning a large mouth to the *Bursariæ*, he includes among them several species in which the existence of a mouth is, to say the least, doubtful."

The genus *Bursaria* is taken as the representative of a distinct family, both by Dujardin and by Perty. The former, who names it "Bursarina," institutes five genera, viz. *Plagiotoma*, *Ophryoglena*, *Bursaria*, *Spirostomum*, and *Condylostoma*. The latter adopts the same name, and ranges the family in his section *Monima*, comprehending Ciliata which, although very contractile, and clothed by a soft integument, always retain their form. The genera included among the Bursarina by Perty are *Lembadion* and *Bursaria*,—the former a new genus established by himself to receive two species which he does not find indicated by Ehrenberg. Dujardin defines the Bursarina as "animals possessing a highly contractile body, very variable in form, mostly oval, ovoid, or oblong; ciliated throughout, and having a large mouth surmounted by a band or surrounded by a spirally curved row of cilia."

The genus *Bursaria* is closely allied to *Paramecium*, from which it is chiefly distinguished by the row of larger, longer cilia about the mouth, extending along the deep fossa in which that orifice is contained. In *Paramecium* the cilia are everywhere of the same size.

Several of the *Bursariæ* enumerated by Ehrenberg have been shown to be *Opalinæ*, and to be destitute of a mouth. These species are *B. Ranarum*, *B. Entozoon*, *B. intestinalis*, and *B. Nucleus*, all which are further remarkable in being parasitic in Batrachia. The *B. cordiformis* is also a parasite of the intestine of the frog, and, although a doubtful member of the genus, has the sanction of Stein to the generic position accorded it.

a. *Sub-genus* Bursaria.—*The inferior (not anterior) lip reaching to the frontal margin.*

Bursaria *truncatella* (M.). *The truncated Bursaria.*—Large, visible to the naked eye; white, ovate, turgid, truncated and broadly excavated in front, where there is a simple row of cilia. In some specimens, Ehrenberg saw half-digested Rotifera and large quantities of vegetable matter in the nutritive cells, and was able, as he thought, by means of carmine given as food, to trace an alimentary canal through the greater part of its course. In each vacuole the food appears surrounded by a clear fluid, which Ehrenberg calls bile. A large bright vesicle is seen below the mouth and somewhat to the left of it, on which side is also a large curved but not articulated nucleus, reaching to the brow or frontal region. In ditches and ponds, amongst rotten beech-leaves. 1-48″ to 1-36″.

B. *Vorticella* (xxiv. 294). — White; large, nearly spherical, and turgid; anteriorly truncated and widely excavated, with a double row of cilia. Found with *Chlamydomonas Pulvisculus* and *Gonium pectorale*, which are sometimes seen within it, as in xxiv. 294. 1-108″.

B. *vorax*.—Large, oblong, rounded at the ends; mouth ample, being one-third the length of the body, and touching the summit of the frontal region. This species has great resemblance to *Urostyla grandis* and *Stylonychia lanceolata*, when their claws and styles are withdrawn. In muddy water in summer. 1-140″ to 1-108″.

B. (*Opalina*) *Entozoon*.—Large, cylindrical, turgid, nearly equally rounded at both extremities; mouth small, near the frontal apex. Found, with the following, in the rectum of *Rana temporaria* (the Frog), in summer and winter.

Perty represents this as a mere variety of *B. Ranarum*. He also treats *B. Nucleus* and probably *B. intestinalis* as other varieties of the same being, and therefore *Opalinæ*.

B. (*Opalina?*) *intestinalis* (*Vibrio Vermiculus*, M.).—Slender, cylindrical, attenuated posteriorly; mouth small, situated below the frontal apex. In this species, as well as in others, Ehrenberg has seen transverse self-division. Found with the preceding. 1-240″ to 1-120″. It is probably an *Opalina*.

B. (?) *cordiformis*.—Reniform, front depressed, mouth slightly curved in a spiral manner; colour white. 1-210″.

This species Stein affirms to be a true *Bursaria*; but Perty makes it an *Opalina*,—a view countenanced by its parasitic nature.

B. *lateritia* (*Trichoda ignita*, M.).—Compressed, ovato-triangular, with the front sharply crested, of a brick-red colour. With Lemnæ, Confervæ, &c. 1-430" to 1-144".

b. FRONTONIA.—*Anterior part of the body (brow) projects beyond the mouth, and is convex.*

B. *vernalis* (*Leucophra virescens*, M.).—Oval, turgid, rounded at the ends, and attenuated posteriorly. The mouth has a wreath of stiff, short bristles, resembling teeth; numerous digestive vacuoles are often filled with large Oscillatoriæ, Naviculæ, &c. (and contain a reddish bile, Ehr.). The progressive digestion of the Oscillatoriæ is interesting to follow:—they are at first elastic and rigid, and of a beautiful blue-green colour, then distinctly lax, flexible, and bright green, becoming afterwards yellowish green, and resolved into separate segments, which at length turn yellow. Amongst Oscillatoriæ in spring. 1-144" to 1-120".

B. *leucas* (XXIV. 295; XXX. 1).—Oblong, cylindrical; extremities nearly equiconvex (bile colourless). This creature has a contractile bladder, with a curious jagged margin near the long open mouth. With Oscillatoriæ, and on the surface of water. 1-144".

B. *Pupa* (XXIV. 296).—White, ovate-oblong, rather acute posteriorly; mouth inferior, and near the frontal apex (see f. 296). 1-280". In chalybeate water, Germany.

B. *flava*.—Ovate-oblong, often acute at the posterior extremity; the mouth occurs in the flat concavity immediately behind the round brow. In bog-water. 1-140" to 1-96".

"This species," says Perty, "differs much, both in its figure and its narrower oral fissure, from true *Bursariæ*, and ranges better with *Panophrys*." Dujardin, again, considers *B. flava*, *B. leucas*, and *B. vernalis* to be merely three varieties of his *Panophrys farcta*.

B. (*Opalina*) *Nucleus*.—Small, white, ovate, attenuated anteriorly; extremities convex. In *Rana temporaria* and *R. esculenta*. 1-240". *Vide* notes on *B. Entozoon*.

B. (*Opalina*) *Ranarum*.—Ovate-lenticular and compressed, subacute anteriorly; the back and belly carinated; often truncated posteriorly; mouth inferior, near the frontal apex. 1-210" to 1-72".

The mouth here described has been diligently sought for by Stein and others; but they can find nothing more than a fold of the surface, with no orifice in it, as shown by reagents. This species is therefore a member of the mouthless group Opalinæa (vide subclass OPALINÆA, p. 269, and Pls. XXII. 46, 47; XXVI. 28, 29).

B. (?) *aurantiaca*.—Ovate-oblong, anteriorly obtuse, posteriorly acute; it has an ash-coloured spot near the mouth. Amongst Oscillatoriæ. 1-280".

B. *arborum*.—Oblong, compressed; very finely ciliated; ends rounded; mouth situated in the anterior third of the body, reaching its frontal extremity; a wreath of larger cilia extending around and backwards from the mouth. Length 1-40‴, double the breadth; vacuoles numerous, and two globular nuclei seen. On moss of trees.

B. *triquetra*.—Ovate-lenticular; very finely ciliated; dorsum flat; venter turgid and slightly keeled, hence an imperfect triquetral figure of the animal; anterior extremity subtruncate; oral fissure long, extending from the frontal end, fringed with a row of strong cilia extending backwards; nuclei two, small; vesicle large, contractile, simple, near the posterior extremity. Swims slowly. 1-36‴. On moss of trees.

B. *Blattarum* (Stein).—Is very like *B. cordiformis*, but more compressed; rounded in front, where there is a very opaque, sharply-defined, coarse-granular, and posterior to it the transverse oval nucleus. In intestine of *Blatta*.

B. patula (Duj. and Perty) = *Leucophrys patula* (Ehr.); *Bursaria virens* (Perty) = *Spirostomum virens* (Ehr.); and *Bursaria spirigera*.

B. *Loxodes* (Perty) = *Loxodes Bursaria* (Ehr.).—Under no circumstances can this species (says Perty) be reckoned with *Loxodes* (Ehr.), or with *Pelecida* (Duj.).

B. *Lumbrici* (Stein) = *Plagiotoma Lumbrici* (Duj.) = *Paramecium compressum* (Ehr.) is a *Bursaria*, not a *Paramecium*, having a row of longer cilia about the mouth and ventral surface.

Genus SPIROSTOMUM (XXIV. 296*–298).—Body elongated, or ribbon-shaped, flexible and ciliated, the frontal region continuous; mouth lateral, spiral-shaped, devoid of teeth, but with a tremulous flap. The locomotive cilia are disposed in rows; those at the mouth are longer, and form, as in *Stentor*, a spiral wreath around it; in *S. ambiguum* the brow and wreath are remarkably long. Vacuoles, to the number of ninety, have been seen filled with coloured food, and the discharge of the latter observed. The anus is placed at the posterior extremity. [A band-like thick gland (nucleus) is seen in *S. virens*, and a bead-like one in other species.] The former likewise possesses a large contractile vesicle, and green granules; in *S. ambiguum* the granules are white. Self-division has not been observed, but Ehrenberg presumes that it takes place transversely.

The band-like or moniliform gland mentioned by Ehrenberg is in fact a pulsating vessel extending almost the entire length of the animalcule. The genus does not belong to Trachelina, but to a family represented by *Stentor*, which Lachmann and others would establish with the name of Stentorina. Perty transfers *Spirostomum* to Urceolarina, in which family it is united with *Stentor*, *Cœnomorpha*, and *Urocentrum*. (See remarks on VORTICELLINA, p. 579.)

SPIROSTOMUM *virens* (*Bursaria spirigera*, D.) (XXIV. 296*).—Ovate-elongate, depressed; truncated anteriorly, and rounded posteriorly. The back is arched, and the under side flat. The green granules are sometimes absent (f. 296*). 1-120″; ova 1-6000″.

S. *ambiguum* (*Leucophrys* [*Trichoda*] *ambigua*, M.) (XXIV. 297, 298.)—White, cylindrical, filiform, flexible; obtuse anteriorly, truncated posteriorly; an elongated frontal region or brow extends beyond the mouth. The long vibrating cilia in front often appear like a proboscis, and were mistaken for such by Müller. The structure of this creature is remarkable, especially the mouth, which is only one-fifth from the tail; thus the frontal region or brow is very long, and the alimentary canal (adds Ehr.), first inflected forwards, returns along the body. From the mouth to the anterior or top of the brow runs a long ciliated furrow (XXIV. 297 and 298). In swimming, they extend themselves, and are readily perceived by the naked eye. In ditches, among decaying oak-leaves and rotten wood. 1-12″.

Both Dujardin and Perty consider this animalcule to be the same as that otherwise described by Ehrenberg as *Uroleptus Filum*.

S. *sempervirescens* (Perty). — Body round, filled with green granules; tail broad, flat, and colourless. Cilia at anterior extremity, clearly seen. The green colour was probably due to the food. 1-96″. Among Lemnæ, but only once. It is allied to *Kondylostoma* (Duj.), which differs from it by its marine habitat.

Genus PHIALINA (XXIV. 299).—The frontal ciliated portion is separated from the non-ciliated body by a constriction or neck; mouth lateral, devoid of teeth. The motion of these creatures is due to the powerful wreath of cilia over the mouth. Ehrenberg says, cilia may possibly be present upon the surface of the body, since Müller described them in *Trichoda mellitea*. A contractile vesicle (perhaps two) is situated posteriorly. Self-division probably transverse.

Dujardin rejects this genus; and, in Perty's opinion, the animalcules it includes are no other than more contracted and younger specimens of *Trachelocerca linguifera* or of *Lacrymaria*. Amongst them are specimens with an evident terminal flap or tongue, and others with incompletely developed necks. Their movements are rapid. (See notes on LACRYMARIA, p. 609.)

PHIALINA *vermicularis* (*Trichoda vermicularis*, M.).—Ovate, attenuated anteriorly; neck very short; colour white. With Lemnæ. 1-240″.

P. *viridis* (XXIV. 299).—Bottled-shaped, anterior part acute, the posterior gradually attenuated; neck very short. 1-280″.

There is nothing distinctive in the assigned characters of this species; the slight difference in form may arise from the varying amount of contraction. The green colour is valueless.

Genus GLAUCOMA (XXIV. 300–302; XXVIII. 4–7).—Body oval, compressed, covered with cilia; mouth provided with a tremulous flap, but no teeth. Ehrenberg described the reception and discharge of food, and the presence of digestive vacuoles, and therefore saw, in these, indications of the existence of an alimentary canal. The large mouth, with its vibratory valves, is situated on the inferior side, in advance of the middle. The anus is situated on the ventral surface, near the posterior extremity, or at the extremity itself. The internal organs are a large ovate gland, a star-like contractile sac, and granules. Self-division transverse or longitudinal.

Glaucoma is comprised by Dujardin among his Paramecina. Perty constructs a family out of this genus, along with *Cinetochilum* (vide CYCLIDIUM, p. 572), which he designates Cinetochilina, and characterizes as animalcules having a mouth on the upper side, surmounted by a vibrating valve (like a tremulous eyelid). Cilia disposed in longitudinal rows. It will be noticed that the mouth is described to be on the upper side instead of the under, as stated by Ehrenberg, with whom we agree.

The anus is on the ventral surface, near the posterior extremity. Lachmann describes two flaps to the mouth, but Perty says the second is simply an expansion of the margin of the mouth.

GLAUCOMA *scintillans* (*Cyclidium Bulla*, M.) (XXVIII. 4–7).—Elliptical or ovate, colourless, slightly depressed; vacuoles large. The vibrating flap appears to be semi-oval or reniform and smooth, and to have a stiff margin. The cilia are seen by employing colour or by pressing or drying the animalcules (XXIV. 300–302). In natural and artificial infusions. 1-280″.

G. *viridis* (Duj.).—Green, oval, short: mouth large, situated nearer the centre than to the anterior margin. 1-860″ to 1-520″. In rain-water butts.

Genus CHILODON (XXIV. 303–309; XXIX. 48–59).—Body irregularly oval, flattened, regularly ciliated: frontal region produced in the form of a broad membranous lip, on one side, resembling a beak; the mouth, situated at its base, and therefore lateral, is furnished with a tubular fascicle of teeth. A round nucleus, one or more contractile vesicles, and transverse and longitudinal self-division have been observed.

This genus along with *Nassula*, *Prorodon*, and two newly-instituted genera, *Cyclogramma* and *Habrodon*, are grouped together in the system of Perty, as a family styled "*Decteria*," which is thus characterized:—"Mouth beset with a circlet of fine bristles. In the first three genera the mouth is lateral; in the remaining two, anterior."

Stein makes *Chilodon* distinct from *Nassula*, by its body being compressed, having a distinct upper and under surface, and a lip-like process above the mouth.

CHILODON *Cucullulus* (*Kolpoda Cucullus*, M.) (XXIV. 303–307; XXIX. 48–59).—Body depressed, oblong or ovate, rounded at the ends; frontal region advancing on the right side. [Ehrenberg states he has often seen the straight alimentary canal, with its grape-like cells, filled with large *Naviculæ*.] Contractile vesicles from two to three; nucleus large, oval near the centre. The circlet of teeth was stated by Ehrenberg to consist of little hard wand-like bodies, which the creature could separate so as to admit into its mouth large living bodies, and afterwards contract or close upon them (XXIV. 308, 309). The anus is at one side of the posterior extremity. In swimming, or creeping upon the surface of Confervæ, the mouth is turned under or below. Its motion is gliding; and it does not revolve in swimming. When the water is coloured, the cilia may be easily perceived, and their disposition when it is dried up. (Figs. 305 and 306 exhibit longitudinal, and 307 transverse self-division.) In fresh and salt water. 1-1150″ to 1-140″.

This species has received a close investigation by Stein. The circlet of teeth (bacillar apparatus, Lachmann) is constructed of no actually separate portions or teeth, as Ehrenberg supposed, but is nothing more than a thickened œsophagus with denser rugæ, or folds, of a chitinous composition. From its lower end a digestive tube extends to nearly the centre of the body.

C. *uncinatus.* — Depressed, oblong, rounded at the ends. The right side of the anterior part is produced, so as to appear like a hook or beak. In vegetable infusions. 1-430″.

This being is, in Stein's opinion, a mere variety of *C. Cucullulus*: the bulging out of the side has a somewhat hook-like process; but this is a mere accidental result following the process of longitudinal self-division (*Infus.* p. 130). It has been seen to encyst itself.

C. *aureus.* — Ovate-conical, turgid, of a golden yellow colour; dilated and obtusely rostrated anteriorly, attenuated posteriorly. 1-140″.

C. *ornatus.*—Ovate subcylindrical, of a golden yellow colour, equally rounded at both ends, slightly beaked; it has a bright violet spot. 1-180″.

The violet spot spoken of has no distinctive peculiarity; it is not a normal coloured gastric fluid, but only a collection of granules, the same as in *Nassula elegans.*

This species, together with the foregoing *C. aureus* and the *Nassula aurea,* are so very similar, that Stein doubts their independent nature, and is more disposed to regard them as developmental phases of the same being.

C. *depressus* (Perty).—Irregular, without a beak, and rounded at both ends; compressed; almost colourless. Transparent, with greyish contents. Upper and under surfaces equally flat. Tooth-cylinder very evident. Switzerland. 1-120″.

Stein states that the body is bilateral, presenting a distinct right and left side, an upper (dorsal) convex and a lower (ventral) flat surface. The anterior end is much flattened and transparent; and being curved towards the left side, gives the whole being a somewhat reniform figure. The depression on this side is always in advance of the middle of the body, just as in *Paramecium Colpoda* and *Colpoda Cucullulus.* The anterior, curved transparent end surmounts the body like a crescentic process, is furnished with longer cilia than elsewhere, and may not inaptly be called the lip. Vibratile cilia cover the body in regular rows, but in very young specimens are invisible except on the lip. The oval nucleus is hollowed by a cavity, within which is a nucleolus. Longitudinal and transverse fission takes place in individuals of all sizes. The former advances from the posterior extremity; the œsophageal (dental) cylinder is not divided, but is produced *de novo* in the newly produced segment: this segment, when first detached, is the *Chilodon uncinatus* (Ehr.). *Chilodon Cucullulus* encysts itself: a soft gelatinous matter is first thrown out around it, which hardens into the cyst-wall; during this process the superficial cilia and the œsophageal cylinder disappear, and at length an oval cyst, with a large nucleus, and two to three contractile spaces alone appear. Gradually a ciliated embryo is developed from the nucleus, resembling in external characters a *Cyclidium Glaucoma.* The embryo escapes from the parent animal; and cysts are sometimes found containing the parent and its offspring side by side within it. The development of embryos may go on until the nucleus is expended. The size of the germ is determined by that of its parent.

Genus NASSULA (XXIV. 310, 311; XXVIII. 2, 3, 11–15). — Covered with cilia; ovoid or oblong; turgid and prominent in front, but without the expansion or beak on one side; mouth lateral, provided with a circlet of teeth, in the form of a wheel (*nassa*). Numerous vacuoles are seen, and in two species, as Ehrenberg states, the discharging orifice. The violet-coloured granular spots noticed in *Chilodon ornatus* occur also in the species of *Nassula,* and are likewise met with in *Bursaria vernalis, Trachelius Meleagris, Amphileptus margaritifer, A. Meleagris,* and *A. longicollis.* "They resemble," says Ehrenberg, "the vesicular glands around the stomachs of the Rotatoria, and are probably of a glandular nature, analogous to biliary glands, and concerned in the process of digestion." The nucleus is large, oval or spherical; and there are one or more contractile vesicles. Only transverse self-division has been observed. They are found in stagnant water, especially where Confervæ and Oscillatoriæ are present.

The violet-coloured supposed digestive glands or cells are, in the opinion of others, simply vesicles coloured by the *Oscillatoria* on which the animalcules feed (p. 312).

This genus and the preceding, *Chilodon*, are very closely allied. Stein finds the best distinctions between the two in the rounded body with the extremities obtuse and rounded off, in the case of *Nassula*, and in the flattened, compressed body, with decided ventral and dorsal surfaces and with a lip-like process, in *Chilodon*.

NASSULA *elegans* (XXIV. 310, 311; XXVIII. 11–15). — Cylindrical or oval, slightly attenuated in front, extremities very obtuse. It is white or greenish, spotted with violet vesicles. Vacuoles, containing Chlamidomonads or other food, may often be observed; and from fifteen to twenty rows of cilia may be seen on one aspect. The animalcule swims backward and forward, turning upon its longitudinal axis. The mouth is easily perceived by the currents when indigo is mixed with the water: it has a circlet containing twenty-six little wands or teeth, which can voluntarily diverge or converge anteriorly. Four round contractile vesicles, placed in a row, occur on the dorsal surface, and doubtless represent four expansions of a continuous contractile vessel along that region. The violet vesicles mentioned are only accidental (*i. e.* not necessary) collections of pigment matter, derived from the food (see p. 312). When self-division ensues, the large central nucleus divides (XXIV. 310, 311; the latter is a young one). With Lemnæ and Confervæ. 1-140″ to 1-120″. *Nassula elegans* is thus characterized by Cohn:—Elongate with rounded extremities; œsophagus funnel-shaped; no cylinder of teeth present as in *N. ornata*. Contractile vesicles two; nucleus elliptic, with nucleolus lodged in a fossa at one end. A large mass of violet granules on under surface posteriorly. It resembles but is smaller than *Paramecium Aurelia*, and has a similar cuticle. With *Bursaria truncatella* and *Ophryoglena atra*. It is smaller than *N. ornata*. Its changes of form are remarkable; often dependent on swallowed joints of *Oscillatoriæ*. Cilia very closely disposed.

N. *ornata* (*N. viridis*?, D.) (XXVIII. 65–71).—Ovate or globular, depressed, of a brownish-green colour, variegated with numerous violet vesicles. The posterior part of the body has a small excavation. Ehrenberg says, there are from six to eight groups of vesicles, forming a wide circle round the mouth, filled with a violet-coloured juice, which is discharged with the excreta, and appears like drops of oil, but soon mixes with and colours the water. It swims rapidly, rotating also on itself, but this only slowly. Among swimming clusters of *Oscillatoriæ*. 1-96″; ova 1-4800″. It has been seen in an encysted state.

N. *aurea*.—Ovate-oblong, nearly cylindrical, very obtuse at the extremities. Its colour varies from golden yellow to a dark brown. 1-120″.

Stein hints it as probable that this species and *N. viridis* (Duj.), *Chilodon aureus*, and *Ch. ornatus* are merely different stages of the same animal.

N. *ambigua* (Stein) (XXVIII. 2, 3).—Rounded, short oval; extremities equally rounded. Entire surface covered by cilia in longitudinal rows. The wedge-shaped oral opening surmounts a very wide pharynx (tooth-cylinder, Ehr.) which may be easily isolated. The contractile vesicle acquires a stellate figure during its contractions and dilatations, like that of *Chilodon ornatus*. The contents are originally colourless, but become tinted green, blue, and red successively, during the process of digestion of the *Oscillatoria* it feeds upon. It occurs encysted, in a transparent, resistant, globular cyst. Length 1-240″; width 1-420″.

N. *concinna* (Perty).—Ovate, hyaline, transparent; covered everywhere with fine granules having an annular arrangement. Dental apparatus particularly delicate, more evident when dried. Cilia very fine; movements sluggish; anal opening at posterior extremity. 1-216″.

Genus LIOSIPHON (Ehr.).—Turgid; ciliated throughout; frontal extremity advanced beyond the mouth, and not auriculate. Mouth opens into a tubular membranous pharynx, provided with a cylinder of teeth.

This is a new genus instituted by Ehrenberg. Its essential distinction from *Nassula* is not pointed out, the only one indicated being the prolongation of the frontal region beyond the oral aperture.

LIOSIPHON *Stromphii*.—Obtuse, ovate; of a variegated green colour; tube of pharynx of a clavate outline. 1-36'''. With *Oscillatoriæ*.

The genera named by Dujardin, having a near affinity with *Bursaria*, are *Plagiotoma*, *Kondylostoma*, *Opalina*, and *Panophrys*. Two others, *Acineria* and *Pelecida* (Duj.), are described as allies of *Trachelius*.

Genus OPALINA.—Already described in the Astomatous family Opalinæa (*vide* p. 569).

Genus PLAGIOTOMA (Duj.).—Body very flat or lamellar, very flexible, irregularly oval; sinuous or emarginate on one side, and sometimes angular behind; covered with cilia in regular rows; mouth lateral, near the middle, at the bottom of the depression, with a row of strong and very numerous cilia in advance of it on its anterior margin, having a comb-like aspect.

PLAGIOTOMA *Lumbrici* = *Paramecium compressum* (Ehr.).—Stein shows this to be a true *Bursaria* (see p. 622).

P. *concharum* (Perty) = *Leucophrys Anondontæ* (Ehr.).—This and the foregoing are, in Stein's opinion, *Opalinæ* (see p. 570).

P. (?) *difformis*.—Irregular, thick, and of a yellowish grey colour from contained molecules. Owing to its want of transparency, the fine short cilia are visible only around the periphery. Motion extremely languid, oscillating and revolving. 1-260''. In the interior of *Anodonta Cellensis*.

Genus KONDYLOSTOMA (Duj.).—Body more or less elongated, cylindrical or fusiform, rather crescentic, with obtuse and flattened ends; mouth very large, bordered by very strong cilia, and placed on one side near the anterior extremity; surface obliquely striated and ciliated. It swallows its food, consisting of other animalcules or of vegetable débris, rather after the manner of *Planariæ* than of Paramecina; for it does not draw it in by the action of its cilia in producing a vortex. It lives only in smooth and pure sea-water among Algæ, &c.

KONDYLOSTOMA *patens*.—Body white, or coloured by the food received; at times vermiform, at others fusiform, and often modified in figure by the bulk of food swallowed.

Genus PANOPHRYS (Duj.) (XXVI. 33).—Ciliated throughout; oval, depressed, contractile; becoming ovoid, or even globular, during contraction; surface marked by straight or oblique ciliated striæ, crossing one another; mouth lateral. Dujardin writes—"Being desirous of characterizing *Bursaria* by the row of large cilia, *en moustache*, which lead to the mouth, I have thought it right to establish a new genus for certain *Bursariæ* of Ehrenberg, which are devoid of this character, and whose mouth is surrounded by only ordinary cilia." Unlike the *Paramecia*, they have no anterior oblique fold or fossa, and are able to contract themselves into a ball. They differ from *Holophrya* by their lateral mouth. They live either in fresh smooth water, or in sea-water among plants.

In Perty's system it constitutes a member of the family Paramecina; and this is its true position, if the cilia are throughout of equal length. Indeed the characters assumed to be distinctive of it from *Paramecium* appear to us inconclusive. A lateral fold or vestibulum leading to the mouth is not entirely wanting, although less developed than in most *Paramecia*; and as to their greater contractile power, this really is questionable, and, if true, is not a proper generic character.

PANOPHRYS *Chrysalis* (XXVI. 33).—Ovoid, oblong, depressed, mouth accompanied by an enlargement, and placed near the front extremity. 1-145" In sea-water.

P. *rubra* (?).—Reniform, covered with fine cilia, and provided with a lateral mouth near the front extremity. 1-370" to 1-325". In sea-water. Only provisionally named.

P. *farcta*.—Ovoid, oblong, filled with particles of a green reddish-yellow hue, or of various mingled colours; mouth lateral, placed between the centre and the anterior third of the body. Its outline is very changeable, its movements rapid. The colour is seldom green. 1-145" to 1-95". In marsh-water among plants. I think it is the animalcule described under three names by Ehrenberg, viz. *Bursaria vernalis*, *B. leucas*, and *B. flava*, and is probably the same as *Leucophra virescens* of Müller.

Although Perty acquiesces in the belief that the yellow-coloured specimens of this species are the *Bursaria flava* (Ehr.), yet he thinks Dujardin wrong in claiming *B. leucas* and *B. vernalis* as varieties.

P. *conspicua* (Perty).—Large; cylindrical, scarcely smaller behind than in front; mouth round. Coloured by food dark green. Swims, revolving at the same time with moderate speed. 1-95". In peaty ponds with Lemnæ.

P. *sordida* (Perty).—Cylindrical, more or less elongated; colour dark, earthy-brown. Mouth small. Cilia covering the body, fine. The position of the internal molecules varies even during examination, and the figure with them. 1-180" to 1-96". Among Charæ.

P. *griseola* (Perty) (XXVIII. 31). — Broad, distended; grey, but transparent, with a fine reticulate appearance; marginal concentric striæ. Sometimes occupied with chlorophyll-granules, when it much resembles *Ophryoglena griseo-virens*. The mouth appears like an elliptic fold in a shallow fossa in the anterior half. It swims and turns on itself with much activity. Transverse fission observed. 1-300" to 1-108". Among decaying plants.

P. *zonalis* (Perty).—Elongated, ovate-cylindrical; hyaline, with a central zone of dark molecules. Extremities equally wide, and rounded. Fissure of the mouth beset with stronger cilia. Movements rather sluggish. Body ciliated throughout. 1-168".

This scarcely seems a true *Panophrys*; for the oral cilia are said to be larger than those on the body, contrary to Dujardin's characters of the genus. Moreover its chief peculiarity, viz. the zone of darker granules, is an insufficient specific feature; and when we are told by Perty that he has only once seen a small specimen, this supposed species has few claims to notice.

P. *paramecioides* (Perty). — Cylindrical, slightly curved, its posterior end somewhat thicker than the anterior; colourless; rows of cilia very numerous and fine. Its molecular structure resembles that of *Paramecium Aurelia*. Movements energetic, twisting. The mouth is placed in a shallow fossa on one side of the body. 1-168". An uncommon form in Switzerland.

There is scarcely anything in the above description which is not compatible with the belief that the animalcule in question is either a *Bursaria* or a *Paramecium*. Moreover, reference to Perty's figures lends no aid to the determination of the question; and we must confess our inability to find, in his illustrations of the genus *Panophrys*, any sufficiently detailed particulars to enable us to distinguish either of the species named as members of it from probable representatives of allied genera.

·Genus BLEPHARISMA (Perty) (XXVIII. 33, 34).—Body compressed, lancet-shaped, with a pointed posterior extremity, whence a deep fossa extends as far as the middle, fringed with longer and straighter cilia than cover the rest of the body. The internal molecules are disposed in longitudinal rows, over which the very fine and inconspicuous cilia are arranged.

BLEPHARISMA *hyalinum* (XXVIII. 33, 34).—Colourless, except when occupied by swallowed chlorophyll-particles. Body thin, flexible, and changeable in form; older specimens are broader. Movements varied and tolerably rapid. Sometimes a few large and non-vibratile filaments appear to issue from the oral fossa.

Among Confervæ and Lemnæ; not common.

B. *persicinum* = *Trichoda striata* (?) (Müll.).—Colour reddish-yellow; young specimens paler. Fission transverse. 1-210″ to 1-144″. At Bern, with the preceding; rare.

Genus ACINERIA (Duj.) (XXVI. 21 *a*, *b*).—Body oblong, depressed, or lanceolate, with a row of cilia extending forwards on one side, which is curved like a sabre. Distinguished from *Trachelius* by the disposition of the row of cilia and the curvature forwards. As in *Trachelius*, the examples of this genus seem destitute of a mouth, and in this respect they especially differ from those of *Pelecida*.

ACINERIA *incurvata* (XXVI. 21 *a*, *b*).—Contractile, oblong, compressed, almost lamellar, round or obtuse behind, contracted and curved in front; a row of cilia runs along the convex edge; and there are five or six granular stripes, and one or more variable vacuoles. 1-590″. In the Mediterranean. It appears to be without a reticulated and contractile integument.

A. *acuta*.—Diaphanous, with granules dispersed in its interior; oblong, compressed, pointed at its two ends; or lanceolate, with one side more convex in front and fringed with cilia. 1-580″. In pond-water.

Genus PELECIDA (Duj.).—Body flexible, contractile, oblong, compressed, rounded behind, curved in the form of an axe in front, ciliated throughout, and furnished with a mouth either visible or indicated by the various objects met with in the interior of the animals.

The animalcule assumed as the type of this genus is the *Loxodes Rostrum* of Ehrenberg. It is stated to differ from the Paramecina by the absence of a contractile integument. Perty introduces it into his system.

PELECIDA *Rostrum* (Duj.) = *Loxodes Rostrum* (Ehr.).

P. *costata* (Perty).—Small; with two to four longitudinal folds. Colourless. 1-320″ to 1-210″. Bern. In ponds, &c.

Genus LEMBADION (Perty) (XXVIII. 50, 51).—Body oval, rather ventricose; with one more or less deep and wide furrow running nearly the entire length of the ventral surface. About twenty rows of cilia on the dorsal aspect; on the margin of the furrows, and at the posterior extremity, are longer cilia.

Internally from two to eight translucent large round vesicles are visible. In Perty's classification this genus is a member of the family Bursarina (see p. 621).

LEMBADION *bullinum* = *Bursaria bullina* (Müll.) (XXVIII. 50, 51).—Hyaline, filled with very delicate molecules; the spherical and often very large internal vesicles differ much, both in number and position. A proboscis-like process occurs at the anterior extremity. Movement tolerably quick, often gyrating. Transverse fission has been observed. 1-240″ to 1-190″. In spring-water. Bern, Lugano, &c. Ehrenberg has erroneously cited the *Bursaria bullina* (Schrank), which is identical with the present species, as the same organism as his *Glaucoma scintillans*.

L. (?) *duriusculum*.—Colourless, ellipsoidal, with a keel or ridge along its upper surface; the under surface somewhat concave. It appears tolerably stiff and firm in consistence; the cilia are very fine, and its movements sluggish. 1-720″ to 1-620″. The position of this animalcule in this genus is doubtful.

Genus HARMODIRUS (Perty).—Body globular, having a moveable elongated lip or proboscis anteriorly.

It is a member of the Trachelina (Perty), and is represented as being in part equivalent to *Amphileptus* (Duj.) and to *Trachelius* (Ehr.).

HARMODIRUS *Ovum*. — The proboscis is not so much a process of the substance of the body, as like a jointed finger or segment; it has a jerking movement in one direction, yet it appears frequently stretched as a stiff process from one side. Cilia extremely fine; thirty rows have been counted on one side; they are most evident near the proboscis. Diastrophy may be frequently witnessed. 1-180" to 1-36". In fresh and bog water, with Lemnæ. This species is doubtless the same as *Trachelius Ovum* (Ehr.) and *Amphileptus Ovum* (Duj.); and we do not conceive the necessity of elevating it to the rank of a genus on account of the slight differential character of the proboscis, as Perty has done.

Genus CINETOCHILUM (Perty) (XXVIII. 35).—Small, short, elliptical, somewhat compressed; vibratile flap on the posterior half.

CINETOCHILUM *margaritaceum* = *Cyclidium margaritaceum* (Ehr.) (see p. 573).

Genus CYCLOGRAMMA (Perty) (XXVIII. 36, 37).—Body small, having the form of *Paramecium*; with concentric striæ on the margin, and a lateral depression near the fore part, where a mouth, with an obscure but peculiar apparatus of from four to seven bristles, is apparent. It is a member of a family called Decteria (see p. 624).

CYCLOGRAMMA *rubens*.—Colour yellow, seldom green, or reddish-white. Mostly rather compressed; rarely subcylindrical. Cilia very fine, with the exception of those on the margin, which are arranged in circular rows. Movement commonly sluggish. The dental apparatus is evident in some examples, but undiscoverable in others. 1-480" to 1-300". Ponds, Bern.

FAMILY VIII.—OPHRYOCERCINA.

Polygastria without lorica; alimentary canal with two distinct orifices, of which only the anal one is terminal. Although their motion is rapid, cilia are perceived near the mouth only, though they probably cover the body; the long neck assists in swimming, and indeed is sufficient alone. Granules (ova?) are seen in all the species, and a contractile vesicle in *T. biceps*. Self-division probable, but not observed.

No such family as Ophryocercina enters into the system of Dujardin, the animalcules composing it being all referred to the genus *Lacrymaria* (see p. 609); and consequently that of *Trachelocerca* is merged in the same.

On the other hand, Perty retains this family name, but, unlike Ehrenberg, comprehends in it both *Trachelocerca* and *Lacrymaria*: moreover he assigns to *Trachelocerca* a wider generic signification, so that it includes also *Phialina* (Ehr.). Again, this family is the representative of one of his three chief sections of Ciliata, viz. Metabolica, thus defined:—"Animalcules very contractile, undergoing protean changes of figure by the expansions and contractions of the body. Cilia scarcely visible upon the body, but clearly seen on its neck-like process." Lachmann describes the œsophagus in this family to be collapsed, or invisible, except during the passage of food.

Genus TRACHELOCERCA.—Characters as above.

TRACHELOCERCA *Olor* (*Vibrio Proteus*, *Cygnus* et *Olor*, M.; *Lacrymaria Olor*, D.) (XXIV. 317, 318, 319).—Spindle-shaped; neck very long and flexible, terminated by a dilated and ciliated mouth. The surface is beautifully reticulate in this and the following species. This creature creeps at the bottom of the vessel containing it, and twines itself gracefully about Confervæ, or the roots of Lemnæ, but swims awkwardly. It elongates and contracts its neck at pleasure, and is altogether an interesting object for the microscope. Greatest length 1-36". It has been found encysted.

T. *viridis* (*Lacrymaria viridis*, D.).—Spindle-shaped, neck simple, very mobile, long, and dilated at the mouth, which has a ciliated lip. Amongst Lemnæ. Length 1-120″; contracted 1-380″.

Perty changes the specific name to "*linguifera*," and has the very good reason for so doing that the green colour is no distinction, because it is often changed to brown, and, besides various intermediate tints, is at times greyish or colourless. Unlike *T. Olor*, the neck is surmounted by a moveable flap or process, styled a tongue, fringed with distinct cilia. Perty speaks of specimens 1-72″ in length.

T. *biceps*. — Spindle-shaped, white; neck long, forked, each segment with a mouth. 1-190″.

This can have no claim as a species, since it is evidently nothing more than an animalcule in the act of longitudinal fission, not far advanced.

T. *Sagitta*= *Vibrio Sagitta* (M.).—Fusiform, white; neck very long; head terminal, opaque. 1-120″. North Sea and Baltic.

FAMILY IX.—ASPIDISCINA.

(XXV. 321–323.)

Distinguished from the preceding family by the presence of a lorica. The alimentary canal has two orifices, of which the discharging one only is terminal. The lorica is firm, very transparent, and combustible, somewhat resembling the shell (carapace) which covers the back of a tortoise; it projects anteriorly a little beyond the body. Long flexible bristle-like organs attached to the abdomen enable the animalcules to climb, while the delicate cilia near the mouth serve both as swimming and purveying organs. Numerous vacuoles have been filled with coloured food by Ehrenberg, who has also seen the discharge of matter posteriorly. An oval nucleus and a contractile vesicle occur in both species. Müller observed self-division, but mistook it for copulation. They are not developed in large masses.

Genus ASPIDISCA.—Characters as above.

Aspidisca *lynceus* (*Trichoda lynceus*, M.).—Lorica nearly circular, truncated at the posterior end, and formed into a hook or beak in front. Mouth furnished with very delicate cilia; five or six bristles (styles) are affixed posteriorly, and from five to eight hooks anteriorly, whereby a resemblance to *Euplotes* and *Stylonychia* is established. A contractile vesicle, near the mouth, and twenty vacuoles have been seen. When burnt upon platina no traces remain. Generally swims or creeps with its back underneath. Amongst Lemnæ and Confervæ. 1-1000″ to 1-576″.

Stein asserts that it is an error to detach this species from *Euplotes*, with which it has the closest affinity, and to elevate it to the rank of a family in immediate contiguity with Colpodea, with which it has no natural relation.

A. *denticulata*.—Lorica nearly circular, under side truncated and denticulated, flat; back arched. The uncini are visible only when climbing. 1-76″.

FAMILY X.—KOLPODEA or COLPODEA.

(XXIV. 312–316; XXV. 325–335; XXVI. 23, 32, 33; XXVIII. 24–26, 31, 33, 34; XXIX. 19, 20, 25–47.)

Animalcules ciliated throughout; the cilia disposed in longitudinal series, and either of uniform length throughout, or of larger growth at particular parts, especially about the mouth. Both mouth and anus demonstrable, always lateral, sometimes situated on the same side, at others on opposite sides of the body.

Except *Amphileptus* and *Uroleptus*, the other genera have both the mouth and anus on the ventral surface. In the former genus Lachmann likewise describes the œsophagus to be collapsed, except during the passage of food, when it presents the appearance of a canal. In all other genera of Kolpodea the œsophagus is distinct, of considerable length, and ciliated, but not thickened at any portion so as to produce the appearance of a dental cylinder "or bacillar apparatus." Coloured food received by all the species. Contractile vesicles one or two in number, and in *Paramecium* of a stellate figure. Nucleus usually rounded, oval or reniform. A red spot, eye-speck or stigma, is common in *Ophryoglena*. Propagation takes place by fission, which may be either transverse or longitudinal; by the production of single living embryos (at least this occurs in *Paramecium* and *Colpoda*); and, in Perty and Carter's opinion, by numerous germs or internal ova. The encysting-process has also been seen in all the genera except *Uroleptus*. The integument of Kolpodea is reticulated, presenting a beautiful diamond-pattern, and having a cilium seated in the centre of each lozenge.

The Kolpodea are highly-organized Ciliata, although inferior in this respect to the Vorticellina. The single circumstance of the limitation of the cilia to the head in the latter family is of itself, according to a well-recognized law of animal life, an intimation of a higher grade of organization.

The genera are disposed as follows:—

Eye absent......	Short protruding tongue. Cilia	absent posteriorly	Kolpoda.
		present everywhere	Paramecium.
	No tongue	With tail and proboscis......	Amphileptus.
		With tail, no proboscis	Uroleptus.
Eye present			Ophryoglena.

This family corresponds generally with that of the Paraméciens or Paramecina (Duj.), thus defined:—Body soft, flexible, variable in form, but mostly oblong and more or less flattened; provided with a loose, reticulated integument, upon which numerous vibratile cilia are disposed in regular series. Mouth present. The genera included are:—*Lacrymaria*, *Pleuronema*, *Glaucoma*, *Kolpoda*, *Paramecium*, *Amphileptus*, *Loxophyllum*, *Chilodon*, *Panophrys*, *Nassula*, *Holophrya*, and *Prorodon*.

Dujardin observes that *Lacrymaria* and *Pleuronema* should probably be placed in a distinct family, since the mouth is rather presumed than demonstrated in them. This is, however, a reason which, in the present day, would not be held valid, as the evidence of a mouth is equally strong in them as in others of the genera enumerated.

Perty also has constructed a family Paramecina, containing the genera *Ophryoglena*, *Panophrys*, *Paramecium*, *Blepharisma*, and *Colpoda*, and briefly characterized as having the body covered with longitudinal rows of cilia, and a lateral mouth often within a fissure. Lastly, Mr. Carter has instituted a new genus, named *Otostoma*, referable to this family, being a close ally to *Paramecium*.

Genus KOLPODA or COLPODA.—Body ovoid, sometimes reniform; a little tongue-like member (a tuft of cilia) inserted in the oral cavity; ciliated in front and partly beneath; eye-speck wanting. The mouth, posterior termination of the alimentary canal, and numerous gastric cells may be demonstrated by coloured food; the two orifices are both on the ventral surface. "Ova," adds Ehrenberg, "occur in delicate strings, forming a sort of network; and their extrusion has been seen in one species. A round contractile vesicle is observable in two species, and two such in another. A large round or oval gland (nucleus) is found in the centre of the body." Self-division both transverse and longitudinal. Their motion is not active, the locomotive cilia being few.

Dujardin, speaking of this genus, says, "Among Ehrenberg's *Kolpodæ*, which should possess a short tongue, and be ciliated only on the ventral surface, but one species, *K. Cucullus*, is with certainty numbered; the *K. Ren*, and *K. Cucullio* have been referred to the genus *Loxodes*, where, indeed, we still leave them. However, Ehrenberg places among the *Paramecia*, under the appellation of *P. Kolpoda*, some large animalcules, ciliated throughout, which we regard as only more developed forms of *Kolpoda Cucullus*."

Stein expresses himself on these views thus (*Infus.* p. 131):—"Under the name of *Colpoda Cucullus* Dujardin has described the *Paramecium Colpoda*, Ehr., appearing either to be unacquainted with the true *Colpoda*, or to have looked upon it as an undeveloped state of *Paramecium Colpoda*." The distinctive characters between these two animalcules and *Chilodon Cucullulus* are thus laid down:—All these three forms are similar in outline, *Chilodon Cucullulus* and *Colpoda Cucullus* being really in most respects undistinguishable. *Paramecium Colpoda* is devoid of the peculiar lip, but has, on the other hand, an expanded anterior extremity (brow), lying over and above the oblique infundibulum, on one side of the body, leading to the mouth. *Chilodon Cucullulus* displays, by the action of chemical reagents, about the middle of its ventral surface its special form of pharynx or œsophagus: it is, besides, ciliated all over; but this is a criterion determinable with difficulty, particularly in young specimens. In *Colpoda Cucullus* the mouth is quite simple, and placed in the lateral depression; the distribution of the cilia is always partial, chiefly limited to the lip. In *Paramecium Colpoda* the mouth (oral aperture) lies at the bottom of a deep longitudinal fold (fissure) on one side of the body, is bounded by two very motile lips, and conducts into a short, thin, walled, ciliated œsophagus; the nucleus is oval, large, homogeneous, and finely granular; and the body is very evidently ciliated all over.

KOLPODA *Cucullus* (M.)(XXV. 324–327; XXIX. 35–47).—Turgid, slightly compressed; kidney-shaped. The concavity in which the oral aperture is situated is occupied by a process called by Ehrenberg a "tongue," but which Stein has shown to be a bundle of longer cilia. The cilia are not distributed over the whole surface, but limited to the convex surface of the anterior half, augmenting in size as they approach its elongated and expanded, wide lip-like or frontal process above the oral fossa, and to a ridge extending downwards and backwards from that fossa. The granules in the interior are frequently so numerous as to render it opaque; they also give it a grey colour. The single contractile vesicle is seated close to the posterior extremity; the nucleus is a circular disc containing a nucleolus, and nearly central in position. This animalcule has not been seen to undergo fission whilst in the free state; the process, however, goes on after it has encysted itself, with various modifications in the results (see Part I. p. 350). Ehrenberg having adopted the notion that the breaking up of a portion of the animalcule was an act of oviposition, thought to further establish it by remarking the presence of numerous Monadiform beings about it, which he concluded were developed from the supposed ova, as the first phase of future *Colpodæ*. Such an interpretation has no evidence to support it, and is rejected by Stein. (XXV. 324, the normal form; fig. 325 represents the animalcule, as Ehrenberg conceived, depositing its ova in a net-like mass, or, as others would interpret it, in process of diffluence; and figs. 326, 327, young animalcules, which resemble *Trichoda pyriformis*.) Common in vegetable infusions. 1-1800″ to 1-280″.

K. (?) *Ren.*—Ovate, cylindrical, kidney-shaped, and rounded at the ends. In river-water. 1-288″.

K. (?) *Cucullio* (M.) = *Loxodes Cucullio*, (Perty).—Compressed, plane, elliptical, slightly sinuated anteriorly. Ehrenberg remarks that neither cilia nor tongue-like member was observable by him, and that its generic situation is therefore uncertain. Perty, however, has noticed such a process. 1-900″.

K. *Luganensis* (Perty).—Large, broad, slightly convex on one side. Oral infundibulum deep. Rows of cilia unusually numerous. Movements slow; internal corpuscles green. 1-130″. It is probably a *Kolpoda*.

Genus PARAMECIUM (XXV. 329–332; XXIX. 25–34).—Body oblong, compressed, ciliated on all sides; mouth lateral, with a tongue-like process; no visual point. The cilia are disposed in longitudinal series; those near the mouth are sometimes longer than the others, and are alone subservient to locomotion, except in two doubtful species. In *P. Chrysalis* the long oral cilia are remarkable. The digestive cells, Ehrenberg proceeds to say, are numerous, amounting to more than a hundred, and are arranged in a berry-like manner along the curved alimentary canal: in five species they have been demonstrated by artificial means, in a sixth by its usual green food. The ova in two species are seen as a granular mass. In all, except one species, male organs are visible. The curious star-like contractile vesicles in the larger species are highly interesting, when physiologically considered, as are also the little black bodies seen in *P. Aurelia*. In four species complete self-division, transverse and longitudinal, has been observed alternately. This genus gives name to a family Paraméciens or Paramecina in the systems of Dujardin and Perty.

Stein makes the uniformity in length and thickness of the cilia a characteristic of *Paramecium*, which distinguishes it both from *Loxodes* and *Bursaria*, which have larger and stronger cilia about the mouth than cover the rest of the body (see p. 285). Ehrenberg's statement that those about the mouth are longer than the rest requires correction; and the instance (*P. Chrysalis*) cited indicates only that this species is not a *Paramecium*. Other particulars requiring revision are, that *Paramecia* have numerous stomachs disposed as offsets upon a curved alimentary tube; that the granular mass in the interior consists of ova. The male organs referred to are the nucleus and contractile vesicle or vesicles. In *P. Aurelia* and *P. Bursaria* Lachmann states that the anus may be frequently recognized, in the form of a small pit on the surface of the animals, even for a considerable time before and after an excretion.

In our remarks on PANOPHRYS we have expressed a doubt as to the independent position of that genus apart from *Paramecium*.

PARAMECIUM *Aurelia* (M) (XXV. 329–332).—Club-shaped, cylindrical, slightly attenuated anteriorly. An oblique longitudinal fold borders upon the very much receding mouth. Ehrenberg states that he has seen small dark crystalline bodies abundant in the frontal region, which, he conceives, are indications of the presence of nervous matter, as such crystalline bodies often accompany it. These creatures appear to him also to have the sense of taste, since in the same group some individuals prefer one kind of food and others another. This may be observed by mixing blue and red colours together, when some will feed upon the former, others upon the latter, as indicated by the colour of the digestive cells: in some the cells have a violet hue. After being fed with colour, they may be dried upon glass or mica, and thus preserved. According to the hypothesis of Ehrenberg, the rays of the star-like vesicle are spermatic ducts, through which the fluid is forced upon the ova in the vicinity by the constantly repeated acts of contraction of the vesicle. The ducts are long, and enter the ovarium at many points (see p. 312 *et seq.*). The expulsion of ova has frequently been observed. The colour of these animalcules, when bearing ova, is white by reflected light, and yellow by transmitted; hence the names "gold and silver little fishes," so often applied to them by Joblot and others; those devoid of ova are colourless. The cilia are best seen when the water is coloured; there are from 26 to 52 longitudinal rows along each side of the body, according to Ehrenberg, who says that in some rows he counted from 60 to 70 cilia, making 3640 organs of locomotion, and that each cilium is placed upon a sort of little knob or articulated base (see p. 285). (Fig. 329, a dried specimen; fig. 330, a creature feeding upon indigo, the particles of which around indicate the currents produced by the cilia; fig. 332, an ideal view, to show the structure of the nutritive organs as stated by Ehrenberg; fig. 331, a young specimen, of the normal shape.) Abundant in vegetable infusions, and increases so rapidly in stagnant waters that some have referred their marvellous abundance to spontaneous generation from elementary primitive matter. 1-120″ to 1-96″.

P. *caudatum*.—Spindle-shaped; obtuse anteriorly, attenuated posteriorly. Not in infusions, but in ponds, amongst decayed sedge-leaves and Confervæ. 1-120″.

P. *Chrysalis* (M.) = *Pleuronema crassum* (Duj.) (xxvi. 23). — Oblong and cylindrical, equally rounded at both ends; cilia about the mouth very long. This species, like *P. Aurelia*, is often developed in such vast myriads that the water has a milky hue, the masses ascending or descending in the fluid: this appearance may be produced by slightly shaking the water. In infusions and in salt water. 1-240″ to 1-190″.

If the uniform length of the cilia be admitted a generic character of *Paramecium*, this species, which has several very long bristly cilia proceeding from the oral fissure, must be excluded. Both Dujardin and Perty have proposed this, and made *Paramecium Chrysalis* the representative of a genus styled "*Pleuronema*."

It is usually filled with greyish molecules and vesicles, and rarely coloured with chlorophyll. Fission longitudinal. The long fibres from the lateral oral fissures are from two to twelve in number, and, though frequently shorter, are at times equal to or even much longer than the body, and serve to vary its movements by their activity.

P. *Kolpoda* (*Kolpoda Ren*, M.; *K. Cucullus*, D.).—Ovate, slightly compressed; ends obtuse, the anterior attenuated and slightly bent like a hook. Found especially in infusions of *Urtica dioica* (the stinging nettle). Perty is disposed to believe this form to be an earlier stage of *P. Aurelia*. 1-240″.

P. (?) *Sinaiticum*. — Elliptical, compressed, the back and under side carinated (keeled); frontal cilia indistinct. Amongst Confervæ, in a brook on Mount Sinai. 1-288″.

P. (?) *ovatum*. — Ovate, turgid; anteriorly attenuated and rounded. In stagnant river-water. 1-288″.

P. *compressum* (*Bursaria Lumbrici*, Stein). — Elliptical or reniform, compressed. An oblique wreath of long cilia reaches to the middle, where the mouth, with its slight tongue-like process, is situated. Found in the river-mussel (*Mya*), and in the intestine of the earthworm (*Lumbricus*). 1-240″ to 1-210″.

Dujardin takes this species as the type of a newly-formed genus, "*Plagiotoma*," characterized especially by its compressed lamellar figure, and by its parasitic habitat. Its cilia are described as disposed in longitudinal rows over the surface (*vide ante*, p. 627).

We agree with Stein that there is no good reason for framing the genus *Plagiotoma*, as Dujardin has done, on the characters of this animalcule. If it have no mouth it should take its place among the *Opalinæ*; and it is to be remarked that though Dujardin clearly saw a deep fold or fissure—a feature of *Opalinæ*—he could not succeed in artificially feeding the animal with coloured food. At all events, it has certainly no right to a place among *Paramecia*, since the crest of longer cilia about the mouth-like fossa refers it (supposing it to have a mouth) to the *Bursariæ*.

P. *Milium* (*Cyclidium Milium*, M.).—Small, oblong, trilateral; rounded equally at both ends. In coloured water the body is seen vibrating. 1-1150″.

P. *Bursaria* = *Loxodes Bursaria* (Ehr.) (xxix. 25–34).—It is not a *Loxodes*, since all its cilia are equal and similar, Ehrenberg being in error respecting the existence of a larger sort in the infundibulum leading to the mouth.

P. *versutum* (Müller) = *Bursaria vernalis* (?) (Ehr.).—Perty revives this species; but Lachmann (*A. N. H.* 1857, xix. 215) thinks it unnecessary to do so, "as there is scarcely any certainty in the synonymy previous to Ehrenberg; and we should never again introduce an older specific name for an Infusorium if it has a name given to it by Ehrenberg, even when it is not improbable he may have overlooked an older name."

b. *var. Alpina* (Perty). — Smaller, plaited, stouter and more cylindrical than *P. versutum*.

P. *griseolum* (Perty). — Little transparent, being filled with greyish molecules; border very delicate. Nine to ten longitudinal plaits on the surface. Movement sudden, frequently oscillating. 1-430."

P. *aureolum.* — Transparent, peach-coloured or golden yellow; plaits strong. Movements sluggish. 1-430".

P. *leucas*=*Bursaria leucas*? (Ehr.).— On one side a horn-like process, and on the other a pair of eminences project. Movements slow.

P. *stomioptycha* (E.). — Oblong, obtusely ovate, turgid; oral aperture large, reniform, cilia long; body marked by circular folds; lip with peculiar appendages; vesicles two, stellate; nucleus elongated, cylindrical. Mouth occupies the anterior third of the body, surmounted, however, by its obtuse frontal end; cilia dense, in longitudinal rows; vacuoles numerous; colour yellowish-white; nucleus above one-third of the entire length, which varies from 1-24‴ to 1-15‴.

Genus AMPHILEPTUS.—Tongue-like process and eye-speck absent; but the body is furnished with a proboscis and tail, and is elongated fusiform or lanceolate. Cilia numerous, disposed in longitudinal series: in one species cilia are not visible; but in this the flexible attenuated extremities of the body serve their office as locomotive organs. In some the tail (foot) and proboscis (brow) are rudimentary. Numerous vacuoles filled with food may be frequently seen; the mouth and anus are usually distinguishable. *A. margaritifer* has a pale rose-red fluid. A contractile vesicle and a nucleus are found; the latter is globular or moniliform. Self-division occurs both transversely and longitudinally, or transversely only.

Speaking of Ehrenberg's distribution of this genus, Dujardin remarks— "This author, whilst assuming the presence of proboscis and tail (as a characteristic), yet refers to the genus animalcules without tail, and dilated and rounded posteriorly; and on the other hand, whilst intent on seeking a distinctive character for his different families in the position of the anus, which he attributes to all his Enterodelous Infusoria, he has left in his genus *Trachelius* several species which to us appear to belong to *Amphileptus*, and has himself several times transferred some species from one genus to the other." The *Amphileptus Anser* is taken by Dujardin as the type of a genus termed *Dileptus*, and *A. Meleagris* of one termed *Loxophyllum*. *Amphileptus* is the name of a genus comprehended by Perty in his family Trachelina, which appears generally equivalent to that bearing the same name in Ehrenberg's system; but it contains besides, *Trachelius vorax*. Cohn remaks that it is imperfectly distinguished by Ehrenberg from *Trachelius*.

The *Amphilepti* are commonly found in the limpid water of marshes or brooks, among aquatic plants.

AMPHILEPTUS *Anser* (*Vibrio Anser* et *Cygnus*, M. = *Dileptus*, D.) (XXIV. 312, 313). — Turgid, spindle-shaped; proboscis obtuse, same length as body; tail short and acute. The neck-like proboscis is in reality a brow or upper lip, the mouth being at the base. Ehrenberg thinks he has seen the anal opening upon the dorsal surface, near the tail. The motion of the body is slow, but that of the proboscis more active. It is very often coloured green with chlorophyll, received as food. Amongst dead sedge-leaves, &c. 1-120".

A. *margaritifer.* — White, slender, spindle-shaped; proboscis acute, equals the length of the body; tail short. The most striking features are the swollen margin of the mouth, and necklace-like series of vesicles disposed along the body. It feeds upon green Monads, like the preceding species in Ehrenberg's figures. Cilia are not shown. Amongst colonies of *Vorticellæ*, &c. 1-72". This species is the counterpart of the preceding; and the distinction found by Ehrenberg in the necklace-like vesicles has no value as such, since these vary both in number and position according to the abundance of food and other external circumstances.

A. *moniliger.*—Turgid, ample, white; proboscis and tail short. It has a necklace-like collection of rose-coloured vesicles. Amongst duck-weed. 1-96" to 1-72".

A. *viridis.*—Turgid, spindle-shaped, green; proboscis and tail short and transparent. Amongst Lemnæ. 1-120" to 1-96".

A. *Fasciola* (*Vibrio Anas, Fasciola*, et *intermedius*, *Paramecium Fasciola*, M.) (xxiv. 314-316; xxix. 19, 20).—White, depressed, linear, lanceolate, convex above, flat beneath. When viewed from above, from ten to twelve longitudinal rows of delicate cilia may be seen, and in the middle of the body two round nuclei, and behind them a contractile vesicle (xxiv. 314, 315, 316). In infusions, in marshy ponds, &c. Perty states that he has found it at an elevation of 5000 feet on the Alps, and also beneath the ice. Cohn has watched its power of encysting itself. (Siebold's *Zeitschr.* 1854, v. p. 430). 1-720" to 1-144".

A. *Meleagris* (*Kolpoda*, M.; *Loxophyllum Meleagris*, D.).—Large, compressed, membranous, broadly lanceolate in shape, with the crest of the back denticulated. The colour of this interesting animalcule is white. On the under side there is a more or less distinct row of eight to ten bright colourless spots. These spots are, however, in no constant number, as Ehrenberg supposed; for they are nothing more than coloured-food vacuoles, which sometimes completely fill the animalcule. With Lemnæ. 1-72". (See notes on NASSULA, p. 625.)

A. *longicollis* (*Kolpoda ochrea*, *Trichoda Felis*, M.).—Dilated; turgid posteriorly; attenuated and elongated anteriorly, like a sword. Amongst Lemnæ. 1-120" to 1-96".

A. (?) *papillosus.*—Depressed, lanceolate, fringed with papillæ; tail and proboscis smooth. Amongst Confervæ. 1-600" to 1-430".

A. *Sphagni.* — Depressed, linear or linear-lanceolate; proboscis truncate and keeled; tail acute; fringed with cilia on one side; green corpuscles occupy the centre, leaving the extremities of the body colourless or hyaline. 1-48" to 1-12". Proboscis is one-fourth the length of the body. Nucleus ovate; cilia disposed spirally. Vacuoles sometimes enclose Bacillaria. Ovules (?) large. Approaches *A. Fasciola* in general characters. On submerged *Sphagnum.*

Genus UROLEPTUS (XXV. 333).—Furnished with a tail; eye-speck, tongue-like process, and proboscis absent. Locomotion effected by the cilia, which cover the body, and are, in three species, evidently disposed in rows. Numerous vacuoles and a mouth have been demonstrated by coloured food; but a discharging orifice has not been satisfactorily determined. Green-coloured granules are evident in two species, but no nucleus or vesicle.

This genus of Ehrenberg (says M. Dujardin), judging from the figures of most of its species, should be in part united with *Oxytricha*. Thus *Uroleptus Piscis* seems identical with *Oxytricha caudata* (Duj.); *U. Musculus* (Ehr.) is, in figure, an *Oxytricha*; whilst *U.* (?) *Lamella* is probably a *Trachelius*, and *U. Filum* is rather allied to *Spirostomum ambiguum*. If these views be correct, *Uroleptus* should be erased from the list of genera. Three species counted in this genus by Ehrenberg are rejected from it by Perty, and allied with *Oxytricha*,—viz. *U. Musculus*, *U. Piscis*, and *U. Lamella*.

UROLEPTUS *Piscis* (*Trichoda Piscis*, M.).—Green; in figure like an elongated top, gradually attenuated posteriorly, forming a thick tail, covered with cilia, those at the mouth largest. Found, in February and March, amongst the floccose brown coat upon dead sedge-leaves, along with *Chlamydomonas* and *Cryptomonas*. Hampstead ponds. 1-288" to 1-44".

Perty doubts if there is any real distinction between this animalcule and the *Oxytricha caudata* (Ehr.).

U. *Musculus* (*Trichoda Musculus*, M.) (xxv. 333).—White, cylindrical, pear-shaped, thickened posteriorly, where it abruptly terminates in a tail. The movement rolling. It is inactive and rigid. With *Oscillatoriæ.* 1-220".

U. *Hospes.* — Greenish, ovate-oblong and turbinate in shape; obliquely truncated and excavated anteriorly; posteriorly terminated by a styliform acute tail. In frog- and snail-spawn. 1-240".

U. (?) *Lamella.* — Transparent, linear-lanceolate, depressed, flat, very thin. In infusions. 1-220".

U. *Filum* (*Enchelys caudata*, M.). — White, filiform, cylindrical; rounded anteriorly; attenuated posteriorly, forming a straight long tail. It is considered a *Spirostomum* by Dujardin and Perty (*vide ante*, p. 623). In stagnant spring-water, &c. 1-48".

Genus OPHRYOGLENA (XXV. 334, 335).—Ovoid, ciliated, with an eye-speck anteriorly. Locomotion effected by the numerous regular longitudinal rows of cilia. Some of the numerous digestive vacuoles are often filled with *Naviculæ*. The mouth is situated in a fossa beneath the brow on one side; and the anal orifice lies upon the dorsal surface, at the base of the little tail. A large central nucleus and one or more contractile vesicles are found; transverse and longitudinal self-division have been observed. A large red or black stigma is always present on the frontal region. These Infusoria are found in stagnant fresh water, but not in infusions.

As Dujardin rightly remarks, this genus differs from *Kolpoda* only by having a stigma or eye-speck; however, he prefers to place it among Bursarina, because the mouth is situated at the extremity of a row of cilia. In this transposition of *Ophryoglena*, Perty does not agree, seeing that it has a narrow mouth, and the closest affinity with *Panophrys*, with which, therefore, he replaces it, along with *Paramecium*, &c., in the family Paramecina. We are disposed to question its claim to a generic position; for the coloured speck is worthless as a distinctive character.

OPHRYOGLENA *atra* (*Leucophra Mamilla*, M.).—Blackish, ovoid, compressed, acute posteriorly. A black stigma is situated anteriorly near the dorsal margin. The mouth is at the bottom of a funnel-shaped cavity, commencing immediately beneath the brow; within this cavity Ehrenberg thinks he has lately seen an oval bright gland. The colourless cilia appear like silver fringe on the dusky animalcule, especially those in front. In turf-hollows. 1-180″.

O. *acuminata* (xxv. 334, 335).—Brown, ovate, and compressed; tail short and acute; stigma red. The brow projects beyond the mouth about the length of the body, or, in other words, is situated about the middle. In turf-hollows. 1-180″.

O. *flavicans*.—Yellow, turgid, ovate, attenuated and rounded posteriorly; stigma red, irregular in shape; the cilia near the mouth longer than in the preceding species; Ehrenberg counted from twelve to sixteen rows at one view. In turf-hollows. 1-144″.

Nothing like a lens can be seen within the eye-speck; but close to it there is an hour-glass-shaped body, transparent and apparently structureless. Its position seems fixed, but it may be detached by diffluence of the animalcule, when it swells up in the surrounding water and often exhibits a central cavity. Its presence is not necessarily associated with the coloured stigma: in *Ophryoglena atra* it is absent; and whilst *Bursaria* possesses this organ, it has no coloured speck. In other Infusoria having stigmata, such as Euglenæa, Peridiniæa, &c., no such organ is discoverable in connexion with them (Müller's *Archiv*, 1856, p. 21). Stein advances, as a distinctive character between *Oph. flavicans* and *Bursaria flava*, the difference subsisting in respect of the nucleolus.

O. *griseovirens* (Perty). — Elliptical, with more or less unequal sides; usually more pointed behind, and rounded in front, where a red or dark pigment-speck is visible. Hyaline, and when strongly magnified reticular; but frequently contains grey or green, and in rare cases brown molecules. The marginal cilia very distinct. Oral fossa in anterior half. Movements quick and revolving. 1-300″ to 1-180″. In ponds, Bern.

O. *Panophrys* (Perty). — Large, oval when seen on the wider side; pointed end posterior; colour greyish yellow; without pigment-speck. When seen on the narrow side, the marginal cilia appear in concentric curved lines, whilst on the broad side the cilia are close together and apparently irregular. Movements slow. Usually swims on one of its wider sides, and but seldom revolves. Mouth wide. 1-144″. Uncommon.

Genus DILEPTUS (Duj.) (XXVI. 26).—This genus belongs to the family "Trichodina" (*ante*, p. 608), and is thus defined:—Animal with a fusiform body, much elongated anteriorly, like a long neck, with a mouth seated at the base of the prolongation; vibratile cilia cover the surface, and are of larger size in front and near the mouth.

Ehrenberg has arranged *Dileptus* with the *Paramecina*, although, unlike the latter, destitute of a contractile reticulated integument. The type of this genus is the *Amphileptus Anser* of Ehrenberg; and the *A. margaritifer* (Ehr.) is also referable to it.

Dileptus *Folium* (Duj.) (xxvi. 26).—Very flexible; lanceolate, contracted in front, with nodular reticulated and irregular stripes, like the veins of a leaf. In river-water. 1-175" to 1-130". Perty remarks that this organism cannot be a species of *Dileptus*.

Genus LOXOPHYLLUM (Duj.) (XXVI. 32).—Very depressed, lamellar, oblique, very flexible; sinuous or undulated along the borders; mouth lateral; cilia in wide parallel rows.

Ehrenberg has comprehended *Loxophyllum* with *Amphileptus*. Perty makes the separation.

Loxophyllum *Meleagris*, the type of the genus = *Amphileptus Meleagris* (Ehr.). The *Trachelius Meleagris* (Ehr.) probably represents also another *Loxophyllum*, as well as the *Kolpoda ochrea* of Müller, which Ehrenberg states to agree with his *Amphileptus longicollis*.

Genus PLEURONEMA (Duj. and Perty) (XXVI. 23), represented by the *Paramecium Chrysalis* (Ehr.), is thus defined by Dujardin:—"Body oval, oblong, depressed; having one large lateral orifice, from which a tuft of long, floating and contractile filaments issues." It has nothing in common with *Paramecium*, he adds, besides its oblong figure; whilst the bundle of long filaments has no analogy, except in the genus *Alyscum*. However, he places it in his family Paraméciens, whilst Perty introduces it as the sole representative of a family "Aphthonia," characterized as having, besides locomotive cilia, other longer ones or filaments.

Pleuronema *crassum* = *Paramecium Chrysalis* (Ehr.). — Ovoid, much elongated, rather depressed; with obtuse ends; finely striated. Lateral orifice at the anterior fourth of the body, with long filaments, some proceeding from the border, others from the posterior extremity. 1-120". In the Mediterranean.

Genus OTOSTOMA (Carter, *A.N.H.* 1856, xvii. 117) (XXVIII. 24–26).—Body ovoid, of a light brown colour, covered with longitudinal lines of cilia. Mouth ear-shaped, in a depression situated about the junction of the anterior with the middle third of the infusorium; buccal cavity broad, short, curved downwards, and a little upon itself outwards, plicated longitudinally in parallel lines. Anus terminal; gland or nucleus long, fusiform, situated between the buccal cavity and the contracting vesicles, which are double and connected with a set of vessels something like those of *Paramecium Aurelia*.

"It is," adds Mr. Carter, "a *Paramecium* closely allied to *Nassula*, and, from the likeness of the oral orifice to the human ear, I propose for it the name of '*Otostoma*.'" Its cysts have been discovered on *Nitella*, and give exit to monadiform beings approaching the parent *Otostoma* in form.

FAMILY XI.—OXYTRICHINA.

(XXV. 336–344; XXVIII. 43–47.)

Possess two separate alimentary orifices, neither of them situated at the extremities, and are not encased by a dense integument (lorica). Their locomotive organs are various, consisting of setæ, vibratile cilia, and non-vibratile styles or uncini, variously situated, and render the creatures active. (Polygastric cells, disposed upon an alimentary tube, were represented by Ehrenberg, except in *Ceratidium.*) A curved line of strong cilia leads towards the mouth, which is situated about the median line at the posterior third of the body, and opens into a ciliated œsophagus. The anus is behind the mouth, on the same ventral surface, near its margin. Complete transverse and longitudinal self-division is observed. The process of encysting may be presumed general; in *Urostyla* Cohn has seen the ulterior development of a ciliated embryo.

Cilia and setæ, no styles or uncini ...	Brow without horns	Oxytricha.
	Brow with horns	Ceratidium.
Styles, or uncini, or both..............	With uncini, no styles	Kerona.
	With styles, no uncini	Urostyla.
	With styles and uncini	Stylonychia.

This family is generally similar to the Keronina of Dujardin,—a family of animalcules, according to this observer, much lower in the scale than many in the families previously described, such as *Kolpoda, Paramecium, Coleps,* &c.

"Processes in the form of styles or hooks characterize both the 'Kéroniens' and the 'Plœsconiens;' but the latter have a shield (lorica), whilst the former are soft and have no sign of an integument. Of the 'Kéroniens' the *Oxytricha* have neither horns nor hooks, but only cirrhi or straight processes, apparently rigid; another genus, '*Halteria*,' has large cirrhi like the preceding, but differs considerably in its mode of life and its movements.

"The *Urostyla* of Ehrenberg, with styles only, and no hooks (uncini), we unite with *Oxytricha*; and his *Stylonychia*, provided with both styles and hooks, with *Kerona*; another genus described under the name of *Ceratidium*, horned anteriorly, but wanting both styles and hooks, seems to be only altered or mutilated *Keronæ*. On the other hand, *Halteria* appears to be included by Ehrenberg among true Urceolaria, in his genus *Trichodina*, although it possesses none of the characters. The *Kéronièns* are found in stagnant water, fresh and salt." Perty has established a family Oxytrichina, which, besides containing two new genera, styled *Mitophora* and *Stichotricha*, excludes *Ceratidium* and *Stylonychia*, referring the species of the latter genus to *Kerona*. After these exclusions and additions, Perty's Oxytrichina include *Oxytricha, Urostyla, Kerona, Mitophora,* and *Stichotricha*.

Genus OXYTRICHA (XXV. 336, 337; XXIX. 21–24).—Styles, uncini, and horns wanting. The body is soft, flexible, oval or oblong, more or less flattened, and provided with cilia and setæ. Their movements are forwards and backwards, often by impulse,—creeping, swimming, and climbing. In all the species, digestive vacuoles are evident; in five, (ova-like) granules; in four, a nucleus; and in five, round contractile vesicles. Transverse and longitudinal division is observed in *O. Lepus* and *O. Pellionella*; longitudinal only in *O. Cicada,* and perhaps in *O. Pullaster*. The *Trichoda Nasamomum* and *T. Æthiopica* (Ehr.) and *Urostyla* belong, in Dujardin's opinion, to *Oxytricha,* and *Oxytricha Cicada* (Ehr.) to the *Plœsconiens*.

Whilst admitting a genus *Oxytricha,* Perty makes two divisions of it, the one corresponding generally to *Uroleptus* (Ehr.), and the second to *Oxytricha* (Ehr.). The differential characters given are:—*a.* Elongated posteriorly, embracing most *Urolepti* (Ehr.); *b.* Rounded posteriorly, equivalent to *Oxytricha* (Ehr.). Under the first division the species enumerated are *O. caudata, O. Piscis, O. Musculus, O. ambigua,* and *O. Lamella*; under the second, *O. proteusa, O. Pellionella, O. gibba, O. Gallina, O. Pullaster, O. Lepus?, O. platystoma, O. decumana*, and *O. fusca*.

OXYTRICHA *rubra* (*Trichoda Piscis* et *T. patens*, M.). — Of a brick-red colour; linear in shape, plane on the under side, and equally rounded at the ends; posterior end provided with setæ. In sea-water. 1-140″.

O. *Pellionella* (*Trichoda Pellionella*, M.) (XXIX. 21-24).—White, smooth; slightly depressed, equally rounded at both ends, often broader in the middle; head not separate; mouth ciliated; tail provided with setæ. Each animalcule has two oval nuclei, and between them a single round vesicle. When self-division commences, four glands are developed; and then the vesicle divides. Ehrenberg counted ten cilia anteriorly, and four or five setæ posteriorly; the anal outlet is at the base of the setæ. In infusions, and throughout Switzerland in swampy ponds along the snow-line of the Alps (Perty). Auerbach has seen it encyst itself (Siebold's *Zeitschr.* 1854, v. p. 430). 1-720″ to 1-280″.

Cienkowsky surmises this species, *O. gibba, Stylonychia pustulata*, and *S. lanceolata* to be one and the same animalcule in different stages of growth and under different circumstances in respect of food, &c. This notion is favoured, he says, by the fact that the animalcule which escapes from an encysted *S. lanceolata* is exactly like *S. pustulata*.

O. *caudata*. — Smooth, white; linear-lanceolate in shape, rounded anteriorly, attenuated posteriorly in the form of a tail, which is provided with setæ. Mouth evident. In fresh and sea-water. 1-576″ to 1-84″. (See STYLONYCHIA *pustulata*.)

O. *platystoma* = *O. eurystoma*.—White, ovato-oblong, under side flat, with marginal setæ; mouth large and ciliated. It swims with a revolving and vacillating motion, and often upon the back. It creeps upon water-plants, in standing bog-water. 1-240″.

O. *gibba* (*Trichoda gibba* et *fœta*, M.) (XXV. 336, 337). — White, lanceolate, ends obtuse, middle enlarged, under side flat, and furnished with two series of setæ, and a large round mouth. This species resembles *O. Pellionella*, but is distinguished by its setæ, the two or three contractile vesicles, and the nucleus. This creature is active, and runs nimbly along aquatic plants in fresh and brackish water. (Fig. 336 an under view, fig. 337 a side view.) 1-240″. It is not equivalent to the *O. gibba* (Duj.).

O. *Pullaster* (*Trichoda Pullaster, Kerona Pullaster*, M.). — Whitish, lanceolate, ends obtuse, ventral surface naked at the middle; the head, indicated by a constriction, is hairy, like the tail. The mouth narrow. In water-butts, streams, and infusions. 1-430″. This form and *O. Lepus* Perty believes to be mere varieties of *O. Pellionella*.

O. *Cicada* (*Trichoda Cicada*, M.). — Ovate, or almost hemispherical, back furrowed and notched, under surface flat. Upon the surface of stagnant water. 1-1440″ to 1-860″.

O. *Lepus*.—Whitish, elliptical, smooth, flat; ciliated anteriorly; provided with setæ posteriorly; the mouth and discharging orifices not distinct; and the nucleus unobserved. In standing water. 1-540″ to 1-96″.

The following additional species are given by Dujardin :—

O. *incrassata*.—Ovoid, long, colourless, fringed posteriorly with rigid setæ. Not so long as *O. Pellionella*, and, unlike it, marine. In the Mediterranean. 1-350″.

O. *Lingua*. — Diaphanous, flattened, flexible, elongated, rounded at each end; without setæ or apparent cilia posteriorly; granules of surface in nearly regular rows. In ditch-water with Confervæ. 1-212″.

O. *ambigua*.—Colourless, oval, oblong depressed in the middle, concave on one side; margin tumid; with very strong locomotive cilia on the concave surface, and with rigid setæ behind. In sea-water. 1-350″.

O. *radians*.—Discoid, red, surrounded by long radiating setæ. In salt or brackish water. 1-520″.

Perty brings forward the following as new species, belonging to true *Oxytricha*, characterized by severally having a round posterior extremity :—

O. *proteusa* (Perty).—Very long, and subcylindrical; nine to twelve times longer than broad. It is sometimes actually four-sided, with wide upper and under surfaces. Mouth a rather curved and ciliated fissure. Cilia very fine, those of the upper surface the more distinct, although faint. Small specimens are colourless and transparent; but larger ones have dark grey molecules or chlorophyll within. Movements tolerably active. Perty once thought this species and *Trachelius strictus* (Duj.) to be young individuals of *Spirostomum*, but he subsequently found examples 1-84" in length.

O. *gallina* (Perty) = *Trichoda gallina* (?) (Müller).—Anterior portion hyaline, flat, with large cilia; molecules grey. Only once seen.

O. *decumana* (Perty).—Outline rather irregular; rather smaller in front than behind, broadest in the middle; ends rounded; upper surface slightly convex, lower flat. Mouth wide. It differs in size from *O. platystoma* and in its outline both from that species and *O. fusca*. In length it equals *Urostyla grandis*, but is much broader. Bern, in ponds. 1-96".

O. *fusca*.—Narrow, elliptical, upper surface convex, lower concave. Oral orifice wide. Colour usually yellowish or blackish-brown. Lives in stagnant and mouldy water. Cilia in front and about the mouth strongest; but no uncini occur there. *Urostyla grandis* differs from it by the uncini on its border. 1-160" to 1-84".

Genus CERATIDIUM (XXV. 338, 339).—Ciliated, with horns on the frontal region, but no styles or uncini. Little of their organization is known; and therefore their systematic position is uncertain. A power of not less than 350 diameters is required to examine these creatures.

CERATIDIUM *cuneatum* (XXV. 338, 339).—Body triangular; front truncated, as also the two horns; upper side smooth. Ehrenberg found this whitish animalcule in 1820, amongst Confervæ, but had not lately seen it. Dujardin believes it to have been a mutilated *Oxytricha*. It vibrates, runs, and climbs quickly. 1-430".

Genus KERONA (XXV. 340, 341).—Cilia and uncini present, but no styles. Body soft, flexible, oval, flattened, and ciliated, with claws (uncini), and perhaps setæ, on the under surface. Vacuoles numerous; the oral (and probably the anal) aperture is upon the ventral surface. One or more contractile vesicles and a nucleus have been seen; but self-division has not been observed.

This genus, instituted by Müller, was at first adopted by Ehrenberg with little modification; but subsequently he transposed almost all its species to his genus *Stylonychia*, on account of their possessing styles as well as uncini. This can scarcely be considered a sufficient reason for the construction of a new genus; and accordingly Dujardin rejects *Stylonychia*, and thus restores the genus *Kerona* nearly to its original importance. As already noted, he likewise adopts *Kerona* as the representative of his family Keronina. Perty coincides with the French naturalist, and rejects both *Ceratidium* and *Stylonychia*, treating the species of the latter as examples of *Kerona*. He remarks that Ehrenberg has very needlessly changed the name *Kerona*, given by Müller, for that of *Stylonychia*.

The *Keronæ*, thus understood, differ from *Oxytricha* only in the form of their cirrhi or processes, the base of which is commonly dilated in the form of a transparent globe, and moveable withal. Moreover they are equally voracious, are abundant in stagnant water and infusions, and capable of being much varied in form.

KERONA *polyporum*.—Whitish, depressed, elliptical, and reniform; a series of cilia surrounds the frontal region, extended from beneath the mouth. Ehrenberg counted above forty vacuoles, many of them filled with brownish (half-digested green) Monads. (XXV. 340 is a back view, and 341 a side view, climbing.) Parasitic on *Hydra vulgaris* (*Microscopic Cabinet*, p. 7). Animals infested with them die. 1-144".

This species is the type of a genus named

Alastor in Perty's system, detached from other Ciliata by reason of its parasitic habits, and placed with *Plagiotoma* (Duj.) and *Opalina* in a family named Cobalina.

K. pustulata (Duj.) = *Stylonychia pustulata.*

K. Histrio (Duj.) = *St. Histrio.*

K. Mytilus (Duj.) = *St. Mytilus.*

K. Silurus (Duj.) = *St. Silurus.*

K. lanceolata = *St. lanceolata.*

K. Calvitium (Müll.), *K. fimbriata* (Müll.), and *Trichoda foveata* and *Tr. Camelus* (Müll.), are probably, according to Dujardin and Perty, mere varieties of *K. pustulata.*

K. Pullaster (Müll.) is cited by Ehrenberg as = *Oxytricha Pullaster*, but, as Dujardin thinks, is only an imperfectly-examined or a deformed specimen of *St. pustulata.*

Genus UROSTYLA (XXV. 342).—Cilia and styles present, uncini wanting; the cilia are thickly disposed in numerous rows, and are longer near the mouth. On the ventral surface, at the posterior end, is a small cleft, provided with non-vibratile setæ. Internally are numerous vacuoles, which may be filled with particles of colour; a nucleus, a contractile vesicle, and delicate granules. Transverse self-division has been observed.

UROSTYLA *grandis* (XXV. 342). — White, semicylindrical, rounded at the ends; slightly enlarged anteriorly, hence club-shaped; styles short; mouth large, one-fourth to one-third the length of the body. It has long cilia on both sides; the discharging orifice has from five to eight little styles on the left side only; stomach-juice colourless. The young animalcules are flatter than the old ones. (XXV. 342, an under view with glands, vesicle, and the cells filled with Bacillaria and coloured matter. Currents produced by the vibration of the cilia about the mouth are also indicated in the drawing.) On slimy dead sedge-leaves. 1-144″ to 1-96″. Perty doubts the independent specific character of this form, and would rather consider it a variety of *Oxytricha fusca*, or more probably of *O. platystoma* in a further developed state; for Ehrenberg admits that the uncini at the posterior extremity are small; and if so, they can scarcely be characteristic.

Genus STYLONYCHIA (XXV. 343, 344; XXVIII. 10, 74–76; XXIX. 18).—Ciliated, and armed with styles and uncini variously disposed.

In one species Ehrenberg thought he had traced the course of the alimentary canal with its numerous digestive cells; in the others, he found, coloured food was received. Transverse and longitudinal self-division occurs in two species; transverse only in a third. In *S. pustulata*, the formation of gemmæ is said to occur. Perty remarks that Ehrenberg, without any sufficient reason, has transferred many of the *Keronæ* of Müller to *Stylonychia*. The granules and molecules are numerous, and often in heaps; one or two nuclei and a contractile vesicle are generally visible.

STYLONYCHIA *Mytilus* (*Trichoda Mytilus*, *Kerona Mytilus*, M. and Perty) (XXVIII. 10). — White, flat, oblong, slightly constricted in the middle, obliquely dilated anteriorly in the form of a mussel. The extremities are so transparent that they give it the appearance of being covered with a shield; but they are soft, flexible, and ciliated. Dujardin observes that the integumentary appendages are very long, consisting of a row of strong cilia in front, a series of uncini and numerous styles behind. The line of cilia leading to the mouth does not reach the centre of the body. Its extremities are so thin and flexible that they yield before obstacles in their movements, like the *Plæsconia Patella*. It differs little from *S.* (*K.*) *pustulata*, except in size and the strength of its superficial processes. The middle of the body is sometimes filled with delicate white granules. Often, however, as Perty mentions, the animalcule is coloured green with chlorophyll received in its food. This animalcule generally has a peculiar, thrusting, forward-and-back movement, but can climb, run, and swim nimbly, usually with the back undermost. Ehrenberg found that a single animalcule lived nine days: during the first twenty-four hours it was developed by transverse self-division into three animals; these in twenty-four hours more formed two each, in the same manner; so that, by self-division only (without ova), these animalcules increase three- or fourfold in twenty-four hours, and may thus produce a million from a single animalcule in ten days. An abundant supply of food favours self-division. In infusions and amongst *Oscillatoriæ*, &c., in stagnant marsh-water. 1-240" to 1-96".

S. *pustulata* (*Trichoda Acarus*, M.; *Kerona pustulata*, Duj.).—White, turbid, elliptical or oval compressed, attenuated at both ends, and having a band of uncini at the middle of the belly. Ehrenberg has seen transverse and longitudinal division, and the growth of gemmæ. In infusions and stagnant marsh-water. 1-144". This species has been seen in the encysted state by Stein and Schneider (XXIX. 18). The white colour is no characteristic, since it is frequently green from food received. Schneider (*A. N. H.* 2 ser. xiv. p. 328) observes that after exclusion from their cysts they present a remarkable resemblance to *Oxytricha caudata*; the posterior extremity in particular is always bent round in the manner represented by Ehrenberg. Pineau calls this animalcule, in his history of a transformation of *Vorticella*, by mistake an *Oxytricha* (see *Ann. d. Sc. Nat.* 1848, ix.). Cienkowsky, however, regards both this species and *St. lanceolata* as phases of existence of the same being as *Oxytricha Pellionella* and *O. gibba*.

S. *Silurus* (*Trichoda Silurus*, *Kerona Silurus*, M., Duj., and Perty).—Small, white, of the form of a mussel; cilia and uncini rather long. In fresh water. 1-280".

S. *appendiculata*.—Elliptical, white, small, and flat; cilia and styles long; the setæ disposed obliquely in fascicles. In fresh water. 1-280".

S. *Histrio* (*Paramecium Histrio*, *Kerona Histrio*, M. and Perty).—Elliptical, white; middle slightly turgid, terminated anteriorly by a cluster of uncini; no setæ. Ehrenberg states that the absence of the three posterior setæ in this and the following species is remarkable, inasmuch as the others possess them. Fission transverse. Amongst Confervæ. Dujardin is inclined to regard this as a mere variety of *S.* (*Kerona*) *pustulata*.

S. *lanceolata*. (=*Kerona lanceolata*, Duj. and Perty) (XXV. 343, 344).—Pale greenish; lanceolate in shape, extremities equally obtuse, under side flat; it has a cluster of uncini near the mouth, but no styles. Ehrenberg saw in one specimen a simple contractile vesicle on the left side, below the mouth, and near it a large oval gland. Green Monads and Bacillaria may be seen in this voracious animal, surrounded with colourless stomach-juice. (XXV. 343 represents an under view, and 344 a side view.) Amongst Confervæ. 1-144" to 1-120". (See note on *St. pustulata*.) Encysted state observed (XXVIII. 74-76).

Genus HALTERIA (Duj.) (XXVI. 31).—Body nearly globular or turbinate, surrounded by long, very fine, retractile cilia, which adhere to the glass, and by their sudden contraction enable the animal to change its place briskly, as if by leaping; a row of very strong oblique cilia occupies the circumference.

The type of this genus is *Halteria Grandinella* (XXVI. 31 *a*, *b*, *c*), called by Ehrenberg *Trichodina*, and placed by him in the family Vorticellina, along with species totally different. Dujardin, however, more correctly refers them to the family called Keronina (see p. 640).

Genus MITOPHORA (Perty) (XXVIII. 46, 47).—Body small, thicker behind, having on one side a row of large cilia, and posteriorly a filament of nearly the length of the body, and either with a simple or a slightly nodose extremity.

MITOPHORA *dubia* (XXVIII. 46, 47).—Hyaline; sometimes filled with green corpuscles; with the characteristic row of larger cilia along one side, and few on the other. Movement sluggish, revolving. It has some resemblance to *Trichoda præceps* (M.). 1-450".

Genus STICHOTRICHA (XXVII. 43, 44).—Lancet-shaped, cylindrical, elongated anteriorly and flat; mouth at this portion; on one side an oblique row of cilia.

STICHOTRICHA *secunda* (XXVIII. 43, 44).—Hyaline; usually filled with grey molecules or chlorophyll-grains; cylindrical or rather compressed, rounded or truncate behind. Cilia on ventral surface short, longer before and behind; it swims rather actively, revolving at the same time; sometimes it crawls. 1-240'' 1-180''.

FAMILY XII.—EUPLOTINA OR EUPLOTA.

(XXV. 345–353; XXVI. 22, 30).

Loricated; alimentary canal with two separate orifices, neither of which is terminal. Organs of locomotion highly developed, similar to those of the preceding family.

This family bears a general resemblance to the genus *Asellus* among the highly-developed Entomostraca. Organs subservient to nutrition are distinctly seen in three genera; and one is remarkable by having a cylinder of wand-like teeth, and a beautiful rose-coloured digestive juice, like that seen in *Nassula*. Granules and a nucleus are found in two, and a contractile vesicle in three species; self-division, transverse and longitudinal, has been observed in one; but gemmæ are not produced. One form is green, the others are colourless or whitish. This family comprises the following genera:—

With cilia; no styles.	Teeth absent	Head distinguished from the body	Discocephalus.
		Head not distinguished from the body............	Himantophorus.
	Teeth present		Chlamidodon.
With cilia, claws, and styles			Euplotes.

This family Euplotina corresponds in part with that of the Plœsconiens of Dujardin, which includes animalcules of an oval or reniform depressed figure, not contractile, but only slightly flexible, and invested with an apparent shield (lorica), which, however, undergoes diffluence like the softer parts. Mouth furnished with vibratile cilia, and often also with cirrhi, in the form of styles or moveable hooks. They swim by means of the vibratile cilia, or crawl by the aid of the other appendages.

The Plœsconiens are distributed into five genera:—*Plœsconia* and *Chlamidodon,* with a visible mouth, the latter also having teeth; *Diophrys* and *Coccudina,* without visible mouth: in the former the cirrhi or processes are grouped at the two ends, in the latter they cover the under surface; *Loxodes* has only vibratile cilia.

The animalcules of the genus *Plœsconia* seem for the most part identical with the *Euplotes* of Ehrenberg; but, as the identification is in some cases uncertain, and as several new species are described by Dujardin, we shall subjoin *Plœsconia,* as an appended genus, along with *Diophrys* and *Coccudina.*

Perty adopts the family Euplota, which he prefers to call Euplotina, and also comprehends in it the Aspidiscina (Ehr.) and the Plœsconiens (Duj.). Its genera are—*Euplotes, Himantophorus, Coccudina* (Duj.), and *Aspidisca.*

Genus DISCOCEPHALUS (XXV. 345, 346).—Styles and teeth wanting, but uncini present; the head is also distinguishable from the body. The organization is unknown, only the non-vibratile uncinated locomotive organs having been specially observed, the characteristic species having been only casually examined by Ehrenberg during his travels in the East. The genus, therefore, must be held a doubtful member of this family.

DISCOCEPHALUS *rotatorius* (xxv. 345, 346).—Transparent; head smaller than the body; mouth rounded at both ends. (xxv. 345 is an under-, and xxv. 346 a side-view.) In the Red Sea. 1-380″.

Genus HIMANTOPHORUS (XXV. 347, 348).—Distinguished by the absence of styles and teeth, by having numerous uncini, and by the head not being distinct from the body. The long bent hooks, generally in pairs, appear like a broad band upon the under side, and serve as organs of locomotion; near them is a row of cilia extending from the mouth to the middle of the body. The mouth, discharging orifice, and numerous vacuoles are distinct. At the posterior margin is a large contractile vesicle; between the row of cilia and margin on the right is a series of glandular (?) spots. Self-division has not been observed.

HIMANTOPHORUS *Charon* (M.) (xxv. 347, 348).—Transparent, flat, elliptical, anteriorly slightly truncated obliquely; cilia short, uncini short and slender. The mouth commences anteriorly, at the lower angle of the triangular bright spot; but the true œsophageal opening appears to be within the curved lorica, at the end of the dorsal row of cilia; the anal opening is near the base of the last cluster of four to six comb-like uncini, which supply the place of styles. (xxv. 347 is a side-, and xxv. 348 an under-view.) In stagnant water and ponds, amongst decayed leaves. 1-180″.

Genus CHLAMIDODON (XXV. 349).—Ciliated mouth, provided with teeth; styles and uncini absent; an oval transparent lorica or shield covers the back, and projects around it; a margin of cilia surrounds the body; they are longer near the brow; short climbing setæ probably exist posteriorly between the cilia. There are distinct vacuoles, as also vesicles containing a beautiful rose-coloured fluid; the mouth has a hollow cylinder of wand-like teeth. Internally are minute green granules and a large, oval, bright central nucleus. Self-division unknown.

CHLAMIDODON *Mnemosyne* (xxv. 349).—Flat, elliptical, sometimes dilated anteriorly, as shown at xxv. 349. It is of a clear green or hyaline hue, with brilliant rose-coloured vesicles; delicate longitudinal lines are seen upon the surface of the animalcule, and appear to be situated on the lorica. Ehrenberg counted sixteen wand-like teeth, disposed cylindrically. The movement is quick and powerful, as in *Euplotes*. With *Zostera* and *Scytosiphon*. 1-570″.

Genus EUPLOTES (XXV. 350–353).—Locomotive organs highly developed and various, in the form of cilia, styles, and uncini, but teeth wanting. Digestive vacuoles have been filled in four species with coloured food; the termination of the alimentary canal is indicated in one species by the discharge, in the rest by the projection of the little shield; the digestive juice is colourless; oval or round simple nuclei occur in three; a single contractile vesicle exists in five, and in a sixth two such. Self-division, transverse and longitudinal, has been observed in one species, and transverse only in two or four others. (See general remarks, p. 645; and PLŒSCONIA, p. 647.)

Perty makes the remark that some of the assumed species of *Euplotes* may be modifications of the same being, due to pressure between the glasses during examination, since the so-called lorica is only relatively hard. The lorica has the form of a carapace or shield, covering only one surface, leaving the under one free. "The styles, which are trailed along, are," says Lachmann, "split up at the apex into as many as eight parts in many species,—*e. g.* in *E. Patella*, in which, too, one style bears a number of small lateral branches."

EUPLOTES *Patella.* — Lorica large, nearly circular, slightly truncated anteriorly; margin transparent, broad; back elevated, gibbous, and covered with a few delicate smooth striæ. The mouth is ciliated on each side; the œsophagus is near the side, below the middle line, the discharging orifice behind the base of the styles. With Lemnæ. 1-280″.

E. *Charon* (*Trichoda Charon,* M.) (xxv. 350–353).—Lorica small, ovate-elliptical, slightly truncated anteriorly, and having granular striæ on the back; twenty to forty cilia were counted by Ehrenberg, but no setæ; a contractile vesicle and one or more nuclei have been seen. In standing water and infusions. Schneider has seen it in the encysted condition. 1-280″.

E. *striatus.*—Oblong, elliptical, slightly truncated anteriorly, uncini only upon the posterior part of the body; four smooth striæ upon the back. Fission longitudinal. In sea-water, but, according to Perty, also in freshwater ponds, &c. 1-240.″

E. *appendiculatus.*—Ovate-oblong, ends rounded, provided with oblique styles and four straight setæ upon the posterior part of the body. In fresh and sea water. 1-240″.

This, says Stein, is the *Plœsconia longiremis* of Dujardin.

E. *truncatus.*—Oblong, with smooth striæ; unequally truncated, and notched anteriorly. It has setæ and numerous uncini. The styles are straight. In sea-water. 1-240″.

Both this and the preceding, Perty believes to be phases of development of *E. Charon* and *striatus.*

E. *monostylus.*—Elliptical, ends rounded, no striæ. It has a single style, like a tail, but no uncini. In sea-water. 1-400″.

E. *aculeatus.*—Oblong, nearly square, ends rounded; it has two crests upon the back, one bearing a little spine in the middle. In sea- and pond-water. 1-430″.

E. *turritus.*—Smooth, nearly circular; it has a long erect spine on the centre of the back. 1-600″ to 1-430″.

E. *Cimex* (*Trichoda Cimex,* M.).—Oblong elliptical, and smooth, provided with cilia, styles, and uncini. In sea-water, and, says Perty, in fresh pond-water. 1-430″.

E. *viridis.*—Large (ample), oblong, truncate in front, with a central obtuse tooth, dorsum flat; granules green. 1-480″. Berlin.

E. affinis (Perty) = *Plœsconia affinis* (Duj.).

E. subrotundus (Perty) = *Plœsconia subrotunda* (Duj.).

Genus PLŒSCONIA (Duj.).—Body oval, more or less flattened, enclosed by an apparent lorica, marked by longitudinal ribs, furnished mostly on one of its plane surfaces with scattered, fleshy, thick processes in the form of stiff hairs, or of non-vibratile hooks, yet moveable and serving the purpose of feet; on the other surface, with a row of vibratile cilia regularly placed, and becoming finer as they recede from the anterior towards the posterior end, where the mouth is situated, and in the direction of which they vibrate.

"In my opinion," adds Dujardin, "a *Plœsconia*, notwithstanding its apparent complexity of structure, is yet an animal as simply organized as those previously considered—having a simple, fleshy, homogeneous substance, which assumes during life a rather complex form, but loses it at the moment of death, having no membrane or fibre to sustain it. The cilia or cirrhi, though of varied form, are still of the same nature, and, I should say, of nearly the same consistence. They have a mouth also, but no anus; vacuoles are formed at the bottom of the mouth, as a result of an impulsive force produced by the vibratile cilia on the surrounding liquid, or they may be hollowed out in any part beneath the surface; lastly, disseminated through the mass are granules varying in kind, and which I cannot admit as determinate organs nor as ova."

We much doubt the necessity of creating this new genus, since all, or nearly all, the species referable to it might be arranged with *Euplotes.* Stein treats *Plœsconia* as synonymous with *Euplotes* (Ehr.), but would retain the former term to designate a new genus represented by *Pl. Scutum* (Duj.), a species, indeed, which is marked by the French naturalist as a doubtful member.

It will be observed that Dujardin denies, as usual, the existence of an anus; this aperture is, however, generally stated to be found on the ventral surface, near the posterior extremity.

PLŒSCONIA *Patella*=*Euplotes Patella* (Ehr.).

P. *Vannus.*—Depressed, oblong, oval; very transparent, smooth, without striæ, 5 to 8 anterior hooks; and 7 to 8 straight styles behind. In sea-water. 1-218″.

P. (?) *Scutum.*—Larger than the preceding, with the band of vibratile cilia extending further backwards, and the posterior styles inflected and sinuous.

"This species," says Stein (p. 158), "differs from the other *Euplotes* both in having prehensile cilia (uncini) not only on the ventral surface, at the posterior portion of the body, but also on the dorsal surface, and in many other peculiarities."

P. *balteata.*—Oval, rather narrower in front, diaphanous, with 5 striæ (ribs); the band of cilia extending five-sixths the length of the body; styles few, feeble. In sea-water; no hooks, as in *P. Vannus.* 1-325″.

P. *Cithara.*—Oval, with ten regularly disposed well-marked ribs; the row of cilia semicircular, extending two-thirds its length; styles not long, and almost confined to the posterior extremity. In stagnant sea-water. 1-290″ to 1-275″.

P. *crassa.*—Oval, oblong; thick, but diaphanous, with some faint signs of ribs; the band of cilia little curved, and extending one-half the length; 6 to 8 curved styles at anterior, and 5 to 7 straight ones at posterior extremity. With the preceding, in sea-water. 1-362″.

P. *Charon.*—Irregularly oval, truncate in front, narrower behind, with well-marked irregular ribs; styles long, not curved. Differs much from *Euplotes Charon* (Ehr.).

P. *affinis.*—Differs from *P. Charon,* by its habitat being in fresh water, and by having its anterior portion narrower, whilst its posterior is more rounded and less plaited.

P (?) *subrotunda.*—Oval, thick, granular within; no distinct ribs; truncated and fissured in front; styles long, thin at each end. In infusions. 1-535″ to 1-475″.

Perty found it under the ice in a pond near the Hospice of St. Bernard, and suggests it to be no more than a variety of *P. affinis* with indistinct ribs (striæ).

P. (?) *radiosa.*—Longer than the preceding, 1-520″ to 1-395″, with long styles radiating from each extremity. In river-water.

P. *longiremis.*—Very depressed, irregularly oval, dilated on the side supporting the cilia, where it is more transparent, with 3 to 4 slightly prominent large ribs; styles numerous, very long and flexible. In sea-water. 1-400″ to 1-306″.

P. aculeata=*Euplotes aculeatus* (Ehr.).

Genus DIOPHRYS (Duj.) (XXVI. 22 *a, b*).—Body discoid, irregular, thick; concave on one side, convex on the other; with long styles grouped at each end; no mouth.

DIOPHRYS *marina* (XXVI. 22 *a, b*).—Oval, with a longitudinal excavation; terminated in front by 5 great vibratile cilia, and behind by 4 to 5 very long geniculate styles. In sea-water. 1-580″.

Genus COCCUDINA (Duj.) (XXVI. 30 *a, b, c*). — Body oval, depressed or nearly discoid, often rather sinuous on the margin; convex, pitted or granular, and glabrous above; concave below, with vibratile cilia, and styles or hooks, serving as feet; without mouth.

Intermediate between *Loxodes* and *Plœsconia*, having the appendages of the latter, and the general figure of the former. Ehrenberg has left the *Coccudinæ* known to him dispersed among the species of *Oxytricha* and *Euplotes*. *Aspidisca* should probably be referred to this genus.

COCCUDINA *costata.*—Oval, obliquely contracted, and sinuous in front; convex and furrowed beneath, where from 5 to 6 very prominent tubercular ribs are found, supporting long cilia; appendages grouped at each end; the anterior thinner and vibratile. In marsh-water and swampy ponds. 1-965″.

C. *crassa.* — Oval; larger and apparently truncated behind; contracted and sinuous in front; convex above, with feebly-marked ribs; anterior appendages in the form of hooks; posterior, of straight styles. 1-20″. Marine, among corallines.

C. *polypoda* (xxvi. 30 *a, b, c*).—Oval, sinuous in front; convex above, and marked with from 7 to 8 narrow ribs; flat below, and furnished with numerous long and flexible styles. In stagnant sea-water.

C. *Cicada*.—Oval, very convex above, granular, without costæ; margin rounded; concave beneath, and there provided with long and flexible styles. Appears the same as the *Trichoda Cicada* of Müller, but not as its supposed synonym *Oxytricha Cicada* (Ehr.), which is like the *Coccudina costata* rather than *C. Cicada*. 1-812″.

C.(?) *Cimex*=*Stylonychia Cimex*(Ehr.).

C. *reticulata*.—A name provisionally applied to an animalcule found in the Seine, having a granular and reticulated surface, and large styles at each end. 1-578″.

C. *crystallina* (Perty).—Hyaline, with from 6 to 7 long costæ on the dorsum, and very short cilia. Outline round. The costæ are less elevated than in *C. costata*. Wet moss and turf on the Alps. 1-900″ to 1-600″.

OF THE GROUP ROTATORIA (p. 392).

(Plates XXXII.–XL., and part of XXV.)

THOSE animalcules which are included in the great division Rotatoria are either destitute of a nervous system, or have merely an isolated ganglion near the head, representing the brain, with a few nervous threads proceeding from it to the body. They have no pulsating heart, nor true blood-vessels in which the blood circulates. The fluid apparently representing the blood occupies the cavity of the body and bathes the external surfaces of the various viscera, as in the lower Crustacea. The alimentary canal is tubular, variously constricted at intervals, often divided into segments, each of which appears to perform special functions. One segment, near the upper extremity of the canal, is provided with a pair of moveable appendages, between which all the food swallowed has to pass, and which may be regarded as teeth or jaws, probably analogous to the gastric teeth of Crustaceans. In many species there are cæcal prolongations of the stomach; whilst the walls of the organ are thick and cellular, having a glandular aspect. The alimentary canal is, with some remarkable exceptions, furnished with an orifice at each extremity, or mouth and anus,—the latter usually opening into a cavity termed the cloaca, or common outlet for the intestine, the oviduct, and the (so-called) water-vascular canals. The interior of the canal is variously supplied with cilia, which are in constant motion. The cæcal and cellular appendages are supposed to be glandular; but their functions, as well as relations to the liver and other chylopoetic organs of higher animals, are doubtful.

The character and instruments of the respiratory functions in the Rotatoria are alike doubtful, but most probably they are performed by the water vascular canals. These are two slender tubes (XXXVI. 6 *e, g*) springing from the cloaca near the anal outlet, and proceeding upwards on each side of the intestine towards the head, where they branch, and sometimes the two anastomose, at others probably terminate in *culs-de-sac*. These canals commence at a pulsating organ (XXXVI. 6 *v*; XL. 5), common to both, and connected with the cloaca. In various parts of their course they are furnished with pyriform appendages (XXXVI. 6 *a*) (tags) varying in number from two to eight on each side. In the interior of each tag is a single large cilium, which exhibits an incessant motion, resembling the flickering flame of a candle, and which most probably promotes the circulation of the water contained in the canals. This water is apparently received from the cloaca into the pulsating appendage, and from it transmitted to the various parts of the tubular system,—a fact especially confirmed by Cohn's observations on *Brachionus militaris*. Hence these water-vascular canals, with their vibratile appendages, appear designed to convey streams of fresh water to the interior of the animal, and thus, by exosmosis, aërate the fluid filling the body of the animal,—the latter being continually driven to and fro during the active muscular movements by which the creature alters its contour.

The Rotatoria are provided with a reproductive apparatus, the female organs being remarkably large and conspicuous (XXXVI. 4 *f*). In the majority of species the latter is the only portion that has hitherto been discovered; but in several, male organs have been found on separate individuals, indicating the bisexual nature of the class—at least demonstrating the diœcious character of some of the species, a feature which will probably be found to characterize the entire family. The ovary consists of a very thin bag of structureless membrane (XXXVI. 4 *f*), distended with clear fluid full of granular molecules, amongst which are some cellular nuclei. The latter successively attract around them portions of the granular fluid, thus forming ova. In several species two distinct kinds of ova are produced by the same individual, one being a true generative product, the other a modified example of gemmiparous generation, and its growth independent of any sexual process. The ovary communicates with the cloaca by means of a narrow but dilatable oviduct. In examples of male animals that have been discovered, there is a remarkable absence of all viscera, except the organs of reproduction (XXXVI. 7, 8). Whether all the Rotatoria are diœcious, or whether some are hermaphrodite, the male organs having hitherto escaped detection, remains to be ascertained.

The bodies of the Rotatoria, unlike those of the Polygastric Infusoria, retain a determinate form, never developing external gemmæ, nor dividing by spontaneous division. Even on emerging from the egg, they possess all the essential features of the matured animal (XXXVII. 16), neither passing through a larval state nor being subject to metamorphosis like Crustaceans and Insects. In the young animal some of the organs, especially the ciliated disks and other external appendages, are imperfectly developed, but they undergo little subsequent changes beyond an increase of size and definitiveness. Some organs, as the red eye-spot, often disappear as the animal progresses to maturity. The anterior extremities of the Rotatoria are furnished with various arrangements of the disks or bulbs supporting numerous cilia (XXXVI. 1 *a* and 4 *a*). These combine to form the rotatory organs, so designated from the wheel-like aspect which they present when fully expanded and with the cilia in motion. Though destitute of true articulated limbs, some species (*e.g.* of *Melicerta*) have appendages not unlike the palpi of Crustaceans and Insects, and which are probably tactile (XXXVI. 18; XXXVII. 17 *d*). Many forms are provided with a prolongation of the posterior part of the body, which is often pointed (XXXVIII. 1), and with the articulations slipping into one another like the joints of a telescope. This organ is sometimes furnished with a terminal disk (XXXVII. 17 *b*), and is used like the tail of the leech, as an organ of attachment. In other cases the disk is wanting, and its place supplied by one or two digital appendages (XXXVI. 4 *h*), employed as anchors; whilst, in swimming, the entire organ appears to become a rudder, regulating the direction in which the animal moves.

The entire animal is invested by a thin pellucid membrane, which, from its extreme tenuity and transparency, readily allows the examination of the internal organs whilst the creature is alive and the viscera fulfilling their functions,—a circumstance that has even made these creatures the favourites of the microscopic observer.

MODES OF OBSERVING THE ROTATORIA.—The magnifying powers most useful in the examination of the Rotatoria are those varying from 200 to 400 linear. For watching their general habits, an object-glass of a half-inch focus, which with an eye-piece giving a power of about 70, is ample; but for examining their internal organization, one of about 300, having an object-glass of from one-third to one-sixth of an inch, is the most useful; for the special examination of more minute structural details, still higher powers are occasionally, but not frequently, needed. We have already remarked that, from the transparency of their bodies, the Rotatoria can be watched with much ease, their internal organs being distinctly visible; and, as these latter are often equally transparent with the general integument, their contents, and the functions they perform, can be investigated with little difficulty. When their general habits are subjects of investigation, it is obvious they must be allowed much of the freedom enjoyed in their natural condition. For this purpose they may be introduced into a small phial of thin white glass with a long narrow strip of similar material in its interior; the latter being so fixed as to be nearer one side of the phial than the other. A blade of grass or one or two stalks of hay may now be introduced between the strip of glass and the proximate side of the bottle; these will attract the animalcules and bring them within the range of the magnifying power. If the phial be now filled with water containing the Rotatoria, they will soon find their way to the vegetable matter, especially if the bottle stands for awhile in the sun, with the side to which the plant is affixed turned to the light. The whole may now be placed under the microscope and readily examined through the lower magnifying powers. To some extent, the same object may be more readily attained by merely transferring small fragments of the half-decayed vegetation floating in the water containing the animalcules, along with a drop or two of the water itself, to a glass slide, covering it over with a piece of thin microscopic glass. But in this case the movements of the creatures are less free, especially if they happen to be of the larger kinds, such as the *Floscularia*. These are often chary of emerging from their protecting cases unless the coast be clear of all impediments. But the freedom of motion, so important to the accurate observation of their habits, wholly prevents the examination of their internal structure. Their perpetual gyration renders it impossible to trace either the forms or relative position of the viscera; consequently they must be controlled. This may partly be accomplished by introducing them between the glasses already recommended without the intervention of any vegetable or other foreign substance. In this case care must be taken to adjust the relations between the size of the thin glass covering and that of the drop of water. If the former be large and the latter small, the chances are in favour of the animalcules being crushed. If these conditions are reversed, their motions will not be sufficiently restrained, neither can the water be preserved from disturbance and vibration. Hence care in hitting the medium of these conditions is essential. The smaller the drop of water the thinner will be the fluid film when the protecting glass is placed upon it, and the more effectually will the vagrant habits of the creatures be controlled. Sometimes it becomes necessary to rupture the animals by further compression, even whilst under examination. The difficulty is to accomplish this without forcing them out of the field of the instrument. It may be accomplished by means of a common sewing needle fitted into a handle, by which pressure may be applied gently but firmly to the thin glass. But this object can be still better attained by means of one of the compressoria provided by opticians: the pressure being effected with a fine screw, the movement can be regulated with the utmost nicety. Thus the animal can be merely fixed in its position, whilst its vital functions proceed without interruption. On increasing the pressure, we obtain increased transparency by reducing the thickness of the animal; and on carrying the motion still further, we can rupture the integument, when the viscera become detached and discharged through the fissure. Thus their minute organization can be more accurately ascertained than when retained *in situ*. In some cases the forms of the various viscera can be readily ascertained from the different hues which characterize them, but in the majority of Rotatoria this guide fails us. Consequently observers have long adopted a plan of feeding the animals with brightly-coloured pigments, such as carmine and indigo, which many of the creatures consume with avidity: a very small quantity of the colour should be rubbed up with a little water, as if for artistic purposes. If the live-box be used in examining the creatures, with the water containing the animalcules a little of this colour must be mixed prior to the cover being placed upon them. But when a common glass slide is employed, it generally suffices to dip a camel's-hair pencil into the diluted pigment and apply it to the edge of the thin glass. The colour usually flows between the glasses, and diffuses itself through the water sufficiently to answer every purpose. Two objects are now attained. The minute coloured particles are thrown into active motion by the ciliary movements of the trochal wreaths, beautifully demonstrating the force and direction of the aqueous vortices set up by the animalcule; and by noting the direction taken by such of the particles as are swallowed, the position of the mouth and œsophageal canal can be traced. These particles usually accumulate in the stomach, distending its parietes; and as the bright colour of the pigment contrasts strongly with the transparent walls of the viscus, its size, form, and position, as well as the structure of its walls, can be readily made out. By prolonging the observation, the same agent enables us to ascertain the direction of the intestine, anus, and cloaca,—since, when the stomach becomes inconveniently full, the creature usually everts the cloaca, brings the anal orifice into contact with the surrounding fluid, and suddenly empties the stomach or bowel of its contents.

There are practical disadvantages attending the use of carmine and indigo, some of which Mr. White appears to have overcome by substituting the red pigment which lines the cornea of the eye of the common house-fly (*Microsc. Journ.* ii. p. 282). By means of a finely-pointed knife, or sharp-edged needle, the large cornea can easily be detached from the head of the insect; whilst a small, stiff camel-hair, or (still better) a small sable pencil suffices to wash the pigment out of the internal concavity of the detached cornea.

It is occasionally desirable to examine the animals by reflected instead of transmitted light, in order that their true colours may be exhibited, as Mr. Gosse has pointed out in the instance of *Philodina citrina*.

Localities for Rotatoria.—These are exceedingly diversified, varying from the wide ocean to the dried-up sediment of the water-spout. There are few circumstances under which water exists, in which Rotatoria may not be found, though they dislike it when its contents are undergoing decomposition. Consequently, though they occur in all vegetable infusions, they are only to be found when the first stage of decomposition has passed away, and they usually disappear again when the water becomes putrid and offensive. After the Monadina, *Paramecia*, and other smaller Infusoria have run their course, and in large measure disappeared, the Rotatoria occupy their places,—a circumstance that has led some observers to suggest the probability of some of these lower forms being the larval states of the higher ones—a view now known to be erroneous.

Some species, especially the *Rotifer vulgaris*, are common wherever water has remained for a little time without disturbance, in cisterns, depressions in the gutters of houses, saucers of flower-pots, and similar situations. A few forms have been found in the interiors of vegetable cells. Thus *Rotifer vulgaris* occurs in the leaf-cells of *Sphagnum*, and in the clavate branches of *Vaucheria*, feeding upon the contained chlorophyll. *Notommata parasitica* and *N. petromyzon*, found within the spheres of *Volvox globator*, in like manner consume the little masses of green protoplasm; whilst *Notommata Werneckii*, like the *Rotifer*, occurs in the cells of *Vaucheria*.

They often abound in the damp moss from the neighbourhood of bogs, streams, and waterfalls. But, besides these special situations, some of them are to be found in almost every ditch and pond in which Lemnæ, Confervæ, and other decaying masses of vegetation abound. Sometimes they play round the plants with incessant action, pushing their slender bodies into every recess in which food may lurk, then backing out again as cleverly as any of their larger aquatic companions can do with fin and tail,—now anchoring themselves to some projecting point by means of their flexible pseudopodia, drawing in their trochal disks with apparent alarm if any other creature brushes past their resting place with unmannerly rudeness; then, forgetting their fears, they again evolve their ciliated wheels, loosen from their anchorage, and launch away into the clear stream, displaying the varied modes of progression so characteristic of different species. But it is only some of the forms which indulge these vagrant habits. The higher forms, such as *Limnias*, *Melicerta*, *Floscularia*, *Lacinularia*, and *Stephanoceros*, are quiet stay-at-home matrons, at least after sowing the wild oats of their youthful days. For a short time only after leaving the ovum do they roam wild and free. They soon settle down, attaching themselves by their false feet to some fixed resting place, where they spend the rest of their lives in sober tranquillity. These home-birds must be sought for amongst the stems and leaflets of *Ceratophyllum*, *Chara*, and the water Ranunculus, more frequently occurring in the clearer streams and ponds than do many of their smaller allies.

Unlike the Monadina and other lower Infusoria, the Rotatoria rarely occur in such profusion as to colour the water. It is occasionally rendered turbid and milky by *Brachionus Palea*, which, in such cases, occurs in vast profusion. *Brachionus urceolaris* and *B. rubens* sometimes present the same conditions. *Typhlina viridis*, found by Ehrenberg in Egypt, coloured the water green. *Lacinularia* forms small transparent gelatinous masses. *Limnias annulatus* occasionally studs the leaves of water-plants in such number as visibly to clothe them in russet brown; and groups of *Conochilus Volvox* appear in small clusters, adherent by the extremities of their pseudopodia, like a group of tadpoles dipped in colourless jelly, from which they can protrude their heads or retract them at will; but sociality does not usually characterize the Rotatoria as it does *Euglena* and similar forms. It is only when the parasitic species have taken possession of some remarkably favourable locality that they so abound as to affect the aspect of the plants on which they dwell, and thus force themselves on the attention of the observer. Usually they must be sought for in a systematic way, without any external indications whether a pool will prove productive or barren. We have, however, rarely been disappointed on examining the green and foul-looking drainage from the manure heap in the farm-yard. Amidst its swarms of *Euglenæ* we have usually found a rich supply of Rotatoria. The true microscopist must not be afraid of soiling his hands, or have a weakness for kid gloves. Some few Rotatoria assume the habits of Entozoa. *Albertia vermicularis* was found by Dujardin in the abdominal cavities of the earthworm and in the intestine of *Limacina*; whilst *Albertia crystallina* was discovered by Schultze in the intestine of *Nais littoralis*.

Capture of Rotatoria.—The modes of capturing the Rotatoria must vary with the species sought, as will be evident from the remarks made in the preceding section. The simplest mode of obtaining the majority of the forms is to collect a quantity of Confervæ, Lemnæ, or the half-decaying masses of the different pond-weeds, filling the vessel with water from the pool in which plants were growing. We have usually found the shallow margins of the pond most productive. On reaching home, the vegetable mass must be well stirred up in the water, in order to detach the animalcules from the plants to which they cling; and, before they have time to re-attach themselves, the water must be poured off into another vessel, through a piece of muslin or very fine net. All the coarse material is thus got rid of, nothing passing through the strainer but water rendered turbid by fine particles of half-decayed vegetation suspended in it. But along with these vegetable atoms the Rotatoria will also pass into the receiving vessel, which must be allowed to stand for a while, allowing the sediment to sink to the bottom, where it will be followed by the animalcules which find nutriment in the half-decayed mass. A small portion of this sediment may now be taken up by means of a narrow glass tube, one end of which must be introduced to the bottom of the vessel, whilst the opposite one is closed by the finger or thumb. On removing the latter, the sediment rushes up into the tube; and if the upper end of the tube be again closed as before, the contained material can be transferred to the live-box or the glass slide. If the tube be held for a few moments in a vertical position, the upper part being still closed with the finger, the vegetable matter and its accompanying animalcules will sink to the lowest part of the water; consequently the first drop escaping from the lower end of the tube will usually be richer than those that follow. If the drop be received upon a glass slide, it must be covered over with a piece of thin glass, when it is ready for the microscope, and, unless the pond has been uncommonly barren, the instrument will reveal a rich harvest of Algæ, Confervæ, Desmidieæ, Diatoms, and Polygastrica; whilst amongst all these the Rotatoria will be found sailing from point to point, exploring all the recesses between the vegetable fragments,—now quiescent, as if contemplating the contents of the larder, then, as if dissatisfied with the prospect, sailing away to some more promising pasture. But when a tempting nook presents itself, this restless locomotion ceases, and they attach themselves to some fixed point either by means of a disk-like foot or by using its terminal joints as an anchor, —their trochal disks being for the time drawn in, and comfortably lodged in the anterior part of the body. Its position being fairly secured, the animalcule evolves its wheels, at first slowly, but soon increasing their speed. A violent commotion amongst the atoms abounding in the water soon indicates the production of a miniature whirlpool, which brings a continuous stream of edible matter within the reach of the hungry traveller. But, though hungry, he is a dainty gentleman, and chooses to select his fare. The bulk of what is drawn towards him by the vortex he has created, not suiting his taste, is suffered to flow by, in a continuous stream, like that left by the rocket in its flight. But everything is not thus allowed to pass: the teeth-like jaws of the animalcule are constantly playing against each other with desperate energy, whilst sudden jerks and contractions indicate that the animalcule has made a capture; and though it is not always easy to see his prey pass down his gullet, the gradual expansion of his stomach proves that he is not labouring in vain. The Monads find to their cost that he is a real Triton amongst the minnows.

Another mode of capturing similar forms is by employing a small net, of very fine muslin firmly fastened to a ferruled hoop of brass or iron, a few inches in circumference, and capable of being fitted to a walking-stick or fishing-rod. It has been recommended that the exterior of this hoop should be grooved, so that nets of various degrees of fineness can readily be employed—these being attached merely by means of an elastic ring of vulcanized indian-rubber, drawn over them and fitting into the metallic groove. By means of a net of this character, the central and deeper parts of a pond can be searched, as, if the gauze be sufficiently fine, the net will retain the larger Rotifera, whilst the water passes freely through it. After making a succession of sweeps through the pond, the net may be everted into a receiver containing clear water, and with a little manipulation the animalcules adhering to it may be washed into the vessel. By means of the same net the fluid may be concentrated until at length the rich products of an hour's fishing may be carried home in an ounce phial. But the muslin must be very fine, or the richest of the game will escape. When the large and exquisitely beautiful Flocularian Rotatoria are the objects of search, a different method must be followed. It is but occasionally that they can be met with; consequently the student must be prepared to give time and labour before he succeeds in discovering these lovely objects; but they are well worth the price. As before observed, *Melicerta*, *Stephanoceros*, and similar forms are found attached to the slender stems and subdivided leaves of *Ceratophyllum*, *Myriophyllum*, *Ranunculus aquatilis*, the *Charæ*, and similar plants. The method of search which we have found the most successful has been to carry with us to the field a narrow phial of clear white glass or a chemist's test-tube, into which portions of such plants as a pond may contain may be introduced along with a little clean water. The unaided eye, when experienced, soon ascertains the presence or absence of the objects sought for; but the search may be further facilitated by means of a pocket-lens of low magnifying power. If, after selecting several fragments drawn from different parts of a pond, these do not reveal traces of some of the Flocularians, it is probable they do not exist there, and we may proceed to some new fishing-ground; but if an isolated individual be detected, every clump of aquatic vegetation in the pond should be carefully searched; for, as is the case with *Volvox* and many other microscopic organisms, there will be found in some part of the water a colony where Malthusianism has no place, and to which the isolated individual first found bears the same relation as the trappers and backwoodsmen of the west do to the swarming communities of Boston and New York.

One remarkable circumstance must be borne in mind by the animalcule-hunter. If he happens to remember a pond where some rare species abounded last year, let him not again turn thither in search of it, as the chances will not be in his favour. These creatures rarely exist in the same water during two successive years. The reasons for this are not easily ascertainable. The remark is equally applicable to *Volvox* and the Desmidieæ. The search will be most productive if prosecuted on new ground. It may be remarked that the Flocularian Rotatoria are usually discovered accidentally, rather than by predetermined search. Respecting the marine Rotatoria but little is known. The class appears to have but few representatives in salt water, contrasted with their abundance elsewhere. Nevertheless some may occasionally be observed whilst examining corallines and seaweeds under the microscope, around which objects they play after the fashion of their freshwater allies. In the ocean we have few or no counterparts of the stagnant pools found on land; those dark holes on rocky coasts, the homes of the *Actiniæ* and the seaweeds, which would otherwise represent ponds and ditches, are too constantly disturbed by the tidal wave to admit of the accumulations of decaying vegetation so favourable to the existence of the freshwater species.

CLASSIFICATION.—The exact place which the Rotatoria should occupy in the zoological scale is as yet undetermined, since discordant opinions are entertained on the subject by some of our most eminent naturalists, as will be seen by a recurrence to Part I. of this work (p. 392). The question can be decided only by a careful study of their development as compared with that of other animals. Most inferior creatures are the *permanent* representatives of conditions which are merely transitional in the advance from the ovum to maturity of some higher form,—the former beings obviously occupying a position subordinate to the latter, inasmuch as they never advance beyond a state which only occurs in the higher animal in its immature and imperfect condition. The Myriapod and the Worm, with their strongly-marked vegetative repetitions of parts, obviously find a temporary representative in the crawling caterpillar, but not in the fully-formed winged insect of which the caterpillar is but the rudimentary larva. Consequently the Worm and the Myriapod must alike be placed below the Insect, if we arrange animal forms in a linear series according to their development. Supposing this method of ascertaining the true zoological position of any class of animals to be correct, the question naturally arises, what larval states of other animals are most closely represented by the permanent forms of the Rotifera? It is clear that the Rotifera have little affinity with the Polygastric Infusoria; for, though the family of Vorticellina amongst the latter animals seems to constitute a sort of inosculating link, the affinity of the *Vorticellæ* to the Rotatoria appears to be rather one of resemblance than of relationship. The history of the *Vorticellæ*, as worked out by Professor Stein, reveals morphological changes wholly dissimilar from what occurs in the Rotatoria, amongst which the encysting-process, so characteristic of the *Vorticellæ*, has no place. This process is obviously one of the phenomena of development by gemmation which is most prevalent amongst the lower animal forms, and becomes less frequent as we ascend, until, amongst the higher classes, it never occurs. In ascertaining the relation of the Rotatoria to the *Vorticellæ*, it is necessary to inquire how far this reproduction by gemmation, as distinct from sexual reproduction, has any existence amongst the former animals; and this is precisely the question which we are as yet unable to answer. It has been suggested that, of the two forms of eggs known to be produced by some Rotatoria, one group consists merely of buds encased in a shell, whilst the others are the true sexual products; but such eminent observers as Professor Huxley and Dr. Cohn are at issue as to which of the two kinds of ova are to be respectively regarded as true eggs or as gemmæ. Dr. Cohn contends that the bodies ordinarily regarded as eggs are merely gemmæ thrown off from the organ believed to be an ovary, without any fertilization by a male animal,—thus accounting for the extraordinary profusion in which these eggs are developed, whilst so many observers have been baffled in their attempts to discover spermatozoa or any male organization. The mode of development which Professor Huxley observed in the ova of *Lacinularia*, and Professor Williamson in those of *Melicerta*, are not incompatible with the idea of their being gemmæ, and the ovary a gemmiferous stolon. Supposing all this to be true, we have, in the formation of these shelled gemmæ, an analogue to the development of the *Vorticella*-buds from the Acinetal condition of the *Vorticellæ*; but the encysting of the entire body of the latter animal, and especially its resolution into a multitude of gemmules, finds no parallel amongst the Rotifera; hence we cannot regard the two classes of animals as having any close affinity to one another.

Professor Owen removes the Rotatoria from the Cuvierian group of Radiata and places them amongst the Articulata, in close alliance with the Crustacea. This idea is a plausible one, and has several supporters. But here we are met by the fact that all the Crustacea, not excluding the Cirripeds and the Entomostraca, pass through a larval condition, resembling which, notwithstanding the assertion of Leydig, nothing has hitherto been observed amongst the Rotatoria; whilst the latter cannot be regarded as having any resemblance to the larval conditions of these higher Crustaceans in any stage of their history. Professor Huxley's suggestion, that they are the permanent representatives of the larval forms of his group of Annuloida (including the Echinoidea, Annelida, Trematoda, and Nematoidea), appears to have many facts in its favour, since it connects them with the articulate division of animals without raising them to the level of true Crustaceans. Burmeister and Leydig hold similar views to those of Owen respecting the close relation existing between the Rotatoria and the Crustacea. Leydig dwells especially upon their external figure, the frequently hardened lorica, the existence in their bodies of striped muscular fibre, their nervous system, the anatomical and physiological phenomena of their sexual life, and, lastly, the supposed fact that the young, at its liberation from the ovum, has not the form of the adult animal, and consequently must undergo a metamorphosis. These arguments, when examined closely, afford feeble support to Leydig's opinion. External form is an unsafe criterion of zoological position. Were it trustworthy, it would bring the Rotatoria nearer to the cilio-brachiate polypes than to the Crustacea. The hardened lorica is nothing more than a modified exo-skeleton, which is as fully developed in the Echinoderms as in the Crustaceans; whilst in the majority of the Lerneadæ (the section of Crustaceans to which Rotatoria bear the closest affinity) this hardened integument is wanting. The existence of striped muscular fibre proves nothing, since Mr. Busk long ago discovered this structure in some of the Acalephæ. The nervous system of the Rotatoria is as yet so imperfectly understood that little reliance can at present be placed upon our knowledge of it; besides which, as Professor Huxley has pointed out, a similar condition to that of the supposed nervous system of Rotatoria exists in Turbellaria; and, lastly, the phenomena of sexual life amongst the Rotatoria are as little understood as is their nervous system. The few instances in which male animals have been found, present some resemblance to the phenomena seen amongst the Lerneadæ; but the subject is equally involved in obscurity in each of the two classes of creatures, whilst Leydig's assertion, that the young Rotifera undergo metamorphosis, appears entirely erroneous. The only facts positively determined indicate that nothing of the kind takes places amongst them, whilst all the Crustaceans, including the Lerneadæ, undergo repeated moults before reaching maturity.

We forbear enlarging on this question of the zoological position of the Rotatoria, as it has already been discussed in much detail in the first part of this work (p. 468 *et seq.*).

The most philosophical mode of subdividing the Rotatoria into families is almost as undetermined as their zoological affinities. Ehrenberg, who led the way in this work of classification, based his primary groups upon the number of divisions and form of the ciliated trochal wreath, subdividing each division according as the animals composing it were loricated or illoricated.

The following table represents his classification:—

With a simple continuous wreath of cilia (Monotrocha)…………………	Margin of ciliated wreath entire (Holotrocha) …	Illoricated …	Ichthydina.
		Loricated……	Œcistina.
	Margin of ciliated wreath lobed or notched (Schizotrocha)………………	Illoricated …	Megalotrochæa.
		Loricated……	Floscularięa.
With a compound or divided wreath of cilia (Sorotrocha) …………	With the ciliated wreath divided into several series (Polytrocha)……	Illoricated …	Hydatinæa.
		Loricated……	Euchlanidota.
	With the ciliated wreath divided into two series (Zygotrocha) …………	Illoricated …	Philodinæa.
		Loricated……	Brachionæa.

N.B. This classification is given more at length at p. 478.

Siebold adopts the classification of Ehrenberg for the Rotatoria, omitting a few genera. Dujardin, on the contrary, regards the principles employed by the great Prussian microscopist in framing his division of these animals as faulty and uncertain; consequently he puts forth a classification of his own, substituting the name of Systolides for the better known one of Rotatoria. He admits four primary divisions of the class, viz.—

1. Those Rotatoria which live fixed to some foreign body by their posterior extremity.

2. Those which employ but one means of locomotion, using their vibratile cilia as instruments, and being always swimmers.

3. Those which exhibit *two* modes of progression, viz. swimming and crawling, after the manner of leeches.

4. Those which creep by uncini, and are destitute of vibratile cilia.

The first of these groups includes only his Flosculariens and Melicertiens. The second contains by far the largest number, and is subdivided into two secondary groups, in one of which the animals have an integument wholly flexible, whilst in the other they have some part of it solid, constituting a lorica or shield. The third section contains only his family of Rotifera, closely corresponding with Ehrenberg's family of Philodinæa; whilst the last comprehends the Tardigrada. These curious animals are now known to have no affinity with the Rotatoria, but belong to the Arachnida, or class of spiders. Indeed, at the time of publishing his book, Dujardin expressed doubts as to the propriety of uniting them with the Rotatoria.

Leydig proposes a new classification of the Rotatoria, or as he terms them, in accordance with his views respecting their nature, *Cilio-crustacea*, which he arranges "according to their forms—whether they are cylindrico-conical, sacciform, or compressed, together with which, as further characters, the condition, presence, or absence of the foot may be employed."

He adopts three primary divisions:—

A. Figure between clavate and cylindrical.
B. ,, sacciform.
C. ,, compressed.

These he again subdivides as follows:—

A.
1. With elongated, transversely-ringed, attached foot.
2. With elongated, jointed foot, retractile, like a telescope.
3. With elongated, jointed, non-retractile foot.
4. With short foot and long pedal forceps.
5. With short foot and pedal forceps which are of equal length with, or somewhat shorter or longer than the foot.
6. Without foot.

B.
1. Foot short.
2. Foot absent.

C.
- *a*. Depressed from above downwards
  1. With a foot.
  2. Foot absent.
- *b*. Laterally compressed.

It will be seen that the classifications of Ehrenberg, Dujardin, and Leydig agree in one feature: they are more or less artificial, being based upon peculiarities of external form and habit rather than upon internal organization. The subdivision of the trochal wreath varies in its extent with the age of the animal, the depth of its sulci increasing with the approach of maturity; consequently the defectiveness of Ehrenberg's system becomes at once obvious. No such changes as we have just referred to affect the internal viscera, except in a minute degree; consequently the latter alone, when thoroughly understood, can furnish the true materials for a philosophical classification. But unfortunately we do not as yet possess such a number of accurate observations as admit of our arranging the various species on this higher basis. For example, the Rotatoria are either monœcious or diœcious: a few have been demonstrated to belong to the latter class; but of the vast majority we are unable to say which of these two features characterizes them. The belief in their monœcious nature has until recently been general; but the possibility of their being all diœcious now suggests itself. Should future observations establish the fact of some Rotatoria being monœcious and others diœcious, the distinction will be one of paramount importance as a basis of classification. But of the internal organization of the vast majority of these animals we unfortunately know little or nothing. A very small number even of the higher forms have been submitted to rigid and accurate scrutiny; consequently the want of material for a natural classification, based on anatomical and physiological data, compels us to fall back upon such as are artificial. (See Part I. p. 477 for additional remarks on classification.)

The relative value of the three systems of Ehrenberg, Dujardin, and Leydig will be a disputed question. Where the purpose to be accomplished is merely the provision of an index (and artificial systems can be little more), the classification in which the distinctions are most readily recognized will best fulfil its purpose. On these grounds we think there is little room for choice between those of Ehrenberg and Dujardin. The two primary sections of the great Prussian naturalist are easily recognized, his four principal subdivisions almost equally so; and the ultimate division of each group into a loricated and an illoricated series not only facilitates the investigations of the young student, but is an element in Dujardin's system, who, by adopting it, recognizes its value. At first sight Leydig's classification would appear to approach nearer to a natural system than either of the others enumerated; but close examination does not confirm this impression, since, in order to arrange the objects in their respective groups, such genera as *Diglena*, *Fur-*

cularia, and *Notommata* have required to be subdivided, part being thrown into one subdivision and part into another. Objects which present such close resemblance as to be capable of arrangement in one generic group can scarcely be so diverse as to justify their separation into different families. The detachment of the fifth section from the fourth, merely because its individuals are furnished with short pedal forceps, would furnish a precedent for classifying birds and quadrupeds according as they have long tails or short ones. These reasons have led us to retain the classification of Ehrenberg for the present, since the advantages afforded by the two newer systems do not seem sufficiently great to justify our abandoning the general plan followed in the previous editions of this work. At the same time we are fully alive to its imperfections, both in its principles and details. Leydig's objection to Ehrenberg's employment of the term lorica is a substantial one, since it is stretching the term beyond what is admissible, to apply it to the delicate investing membranes of *Floscularia* and *Stephanoceros*, or to the gelatinous envelope of *Conochilus*. Consequently, though for reasons already advanced we retain the subdivisions of the Prussian microscopist, we extend his definitions of his third series of groups: instead of defining them as "*loricated*," and "illoricated," we would describe them as "loricated, or usually provided with a hard investing layer," and "illoricated, or unprovided with a hardened investing layer."

Leydig's objection, that such animals as Ehrenberg indicates by the terms Polytrocha and Zygotrocha have no existence, is ill founded. There is no question that the ciliated lobes of the head are divisible and distinct in a large number of species; and being so, they become as good characteristics of families as do Leydig's long or short pincers to the foot.

FAMILY I.—ICHTHYDINA.

Rotatoria with a single continuous rotary organ, not cut or lobed at the margin; destitute of lorica or indurated integument. In *Ptygura* and *Glenophora* the wheel-like organ is in the form of a circle, and is an instrument of locomotion. In the other genera it is long elliptical, and on the ventral surface. *Chætonotus* and *Ichthydium* have each a *forked* foot-like process, and the rest of the genera a simple one. A long simple alimentary canal, with a long œsophagus, apparently without teeth, occurs in *Chætonotus* and *Ichthydium*. *Glenophora* has a short œsophagus, with two single teeth; and *Ptygura* an elongated stomach and three teeth. Glands are seen only in *Chætonotus* and *Ptygura*. No cæca exist in any of the genera. The male reproductive organs, not hitherto discovered; those of the female consist, in *Ptygura* and *Ichthydium*, of a large ovarium containing one or more developed ova. The two red eyes seen in *Glenophora* are supposed by some to indicate the existence of a nervous system as yet undiscovered.

Ehrenberg's classification of this family will be found in p. 478 of the General History. It is probably the weakest which Ehrenberg has established, being admitted neither by Dujardin nor Leydig. Dujardin does not recognize the genus *Glenophora*, neither does Siebold, whilst Leydig rejects both it and *Ptygura*, regarding them as immature forms of some other species. *Ptygura* especially, the latter writer suggests, may be the young *Melicerta ringens*; but this idea Professor Williamson's observations have shown to be erroneous; consequently the genus must be retained until its immature condition is better established than at present. Dujardin comprehends *Ptygura* in his family of Melicertiens, whilst he rejects *Ichthydium* and *Chætonotus* from amongst the Rotatoria, believing them to be Polygastric Infusoria,—a conclusion with which we are strongly disposed to agree.

Genus PTYGURA.—Eyes and hair absent; foot simple, truncated, cylindrical. Body campanulate, oblong. Rotary organ simple, and nearly circular. Numerous tooth-like bodies, adhering to the bulb of the œsophagus, two glands, a small narrow œsophagus, an elongated stomach, and a subglobular rectum constitute the apparatus of nutrition. An ovarium and a contractile vesicle have been observed, but no visual organs.

This genus is comprehended in the family Melicertiens of Dujardin, along with *Lacinularia*, *Tubicolaria*, and *Melicerta*, and is made to include the species distributed by Ehrenberg in the several genera *Ptygura*, *Œcistes*, and *Conochilus*; for Dujardin states that the individuals of these three genera present no further difference than is seen in the gelatinous envelope, which surrounds the two last, forming in *Œcistes* a distinct tube for each individual, whilst it includes the individuals of *Conochilus* in a common globular mass, and is absent in *Ptygura*. The same author would name *Œcistes crystallinus* "*Ptygura crystallina*," and the *Volvox conochila* "*Ptygura Volvox*."

PTYGURA *Melicerta*. — Transparent; body cylindrical, club-shaped, turgid anteriorly, with two little curved horns at the mouth, and a single short tube at the neck (?). The tail-like foot always remains transversely folded (wrinkled), as seen in xxv. 354, which represents the under side. When swimming, a ring-like simple vibratile organ is thrust out, with a lateral notch. The two jaw-like parts of the œsophageal bulb have numerous teeth, as represented at xxv. 355. 1-140″.

Genus DASYDYTES (Gosse).—Eyes absent; body furnished with bristle-like hairs; tail simple, truncate.

This genus, according to Ehrenberg's description of Ichthydina, must follow after *Ptygura*.

DASYDYTES *goniothrix*.—Hairs long, each hair bent with an abrupt angle; neck constricted. 1-146″. Found at Leamington.

D. *antenniger*.—Hair short, downy; a pencil of long hairs at each angle of the posterior extremity of the body; head furnished with two club-shaped organs resembling antennæ. 1-170″.

Genus ICHTHYDIUM.—Tail cleft or forked, foot-like; no eyes or hair; currents at the mouth and along the ventral side indicate the existence of a vibratile organ, which not only serves for swimming but likewise for creeping. A long œsophagus, a thick simple conical alimentary canal, and sometimes a large single ovum, comprise our knowledge of their organization. It is probable that a cylinder of little wand-like teeth exists (see Part I. p. 380).

ICHTHYDIUM *Podura* (*Cercaria Podura*, M.). — Straight, oblong, often slightly constricted anteriorly, where it is turgid, and sometimes three-lobed. It is colourless or whitish, but during repletion sometimes appears yellowish; the ventral surface is flat and ciliated, the dorsal arched and smooth. The large dark ovarium has been seen by Ehrenberg. It seldom swims, but mostly creeps. xxv. 356 exhibits a full-grown animalcule (ventral side). Among Confervæ and Oscillatoriæ. 1-440″ to 1-140″.

Genus CHÆTONOTUS.—Dorsal surface covered with hairs; tail forked; eyes absent. Locomotion is performed by means of a double row of cilia upon the ventral surface, forming a band-like rotary organ. The nutritive organs consist of a tubular mouth, probably provided with a cylinder of teeth, a long thin œsophagus, and a long conical stomach (*trachelogastricum*), upon whose upper thick end (in the large species) two semiglobular glands are seen; at certain periods from one to three large ova are formed posteriorly, but the ovarium in which they are developed has not been directly observed; male reproductive organs unknown. They are sluggish in their movements, except in creeping; they rarely swim. (See Part I. p. 380 *et seq.*)

CHÆTONOTUS *maximus* (XXXI. 29, 30).—Elongated, slightly constricted anteriorly, turgid and obtusely three-lobed; hairs upon the back short and equal. From his latest observations, Ehrenberg states the mouth to possess teeth, of which he has counted more than eight; he once saw the exclusion of ova immediately over the foot-like tail. It creeps but slowly. 1-216″ to 1-120″. (See p. 381.)

C. *Larus* (*Trichoda Acarus*, *Anas* et *Larus*, M.). — Elongated, slightly constricted anteriorly, where it is turgid and obtusely triangular; the posterior hair on the dorsal surface is longest. Ehrenberg has seen only one large ovum; he states that the bodies of those bearing ova were thick posteriorly, though, under other circumstances, the head is broadest. It appears to have eight teeth. The dorsal hairs, which are arranged in longitudinal rows, destroy the transparency of the body. XXV. 357 is a dorsal, and 358 a side view. Ova one-third the length of the body. In muddy water. 1-720″.

C. *brevis*.—Ovato-oblong, slightly constricted near the turgid front; dorsal hairs few, the posterior longest; ova small. 1-340″.

As before stated, Dujardin places this genus, together with *Ichthydium*, among the Infusoria (Polygastrica, *Ehr.*), but in a subclass of them, called symmetrical, along with *Coleps* and a doubtful genus named *Planariola*. These genera are distinguished by him from all other Infusoria in having a symmetrical figure.

One species of *Chætonotus* described by Dujardin is probably new, although it may be, as he remarks, but the *C. maximus* of Ehrenberg.

The following are its characters:—

C. *squamatus*.—Elongate, narrowed at its anterior third, but expanded in its posterior half. 1-130″ to 1-135″. Covered with short hairs, which are dilated in a scale-like form toward the base, and regularly imbricated. In long-kept sea-water brought from Toulouse.

Genus SACCULUS (Gosse) (XL. 17, 18).—One eye, frontal; body destitute of hair, and without a foot; rotary organ a simple wreath; alimentary canal very large; jaws set far forward, apparently consisting of two delicate unequal *mallei* and a slender *incus*; very evanescent; eggs attached behind after deposition.

This genus comes nearest to *Glenophora*, but, unlike the latter, has but one eye. Perty's genus *Ascomorpha* appears identical with *Sacculus*.

SACCULUS *viridis*.—Pear-shaped; flattened ventrally, the anterior end the narrower; head conical-pointed, surrounded by a wreath of long cilia; digestive canal occupying nearly the whole body, and always filled with a substance of a rich green hue in masses. 1-150″. This curious animal, found in considerable number in a little pool on Hampstead Heath, must be placed in this family, according to Ehrenberg's system; but the mode of carrying its eggs indicates an affinity with the Brachionæa. The *Ascomorpha gemanica* of Leydig is identical with the above species.

Mr. Gosse has ascertained that this species is diœcious. XL. 17 represents a newly-born male, and 18 a female with ova attached.

Genus GLENOPHORA (XXV. 359).—Eyes two, placed anteriorly; rotary organ frontal, circular; tail bifid, truncated. The alimentary canal is short, thick, and conical; it sometimes contains green matter. The two protruding forceps-like bodies in the middle of the rotary organ may, says Ehrenberg, be considered teeth; glands are indicated by knot-like turbid bodies. The eyes are sharply circumscribed, and situated at the frontal region. Dujardin and Leydig believe this genus to be based on young animals, and as such unsatisfactory.

GLENOPHORA *Trochus.*—Ovato-conical, truncated and turgid anteriorly, attenuated posteriorly, with a false foot; the eyes are blackish. It swims quickly, like a *Trichoda* or free *Vorticella.* The genera *Monolabis* and *Microcodon* have similar forms. (xxv. 359, 360 represent two animalcules, the latter having the stomach filled with a green substance.) 1-570″.

FAMILY II.—ŒCISTINA.

Rotatoria with a single rotary organ, entire at the margin, and an external gelatinous envelope. This family contains only two genera, which possess a more developed internal organization than any hitherto described. They are further provided, according to Ehrenberg, with locomotive organs, internal muscular bands, a tail-like foot without terminal pincers; nutritive organs, among which is a crushing apparatus consisting of teeth in rows; two pancreatic glands, and red visual or eye-spots. In *Conochilus* alone he thinks he observed ganglia with nervous fibrillæ, male organs, vessels, and two filiform tremulous organs or gills.

This description is of course modified by the views Ehrenberg entertains respecting the various organs contained in the bodies of these animals. We have no evidence that the *glands* are pancreatic; the "male organs" are the water-vascular canals of other writers, of which the tremulous organs or gills are external appendages; the "vessels" are muscular bands; and the nervous fibrillæ and ganglia have a more than doubtful existence.

External envelope ...	Special for each animalcule	Œcistes.
	Compound, or common to many animalcules............	Conochilus.

Both the *Œcistes* and *Conochilus* are included by Leydig in his first division of Rotatorial animals.

Genus ŒCISTES (XXV. 361–364).—Characterized by each animalcule having a separate lorica. The two eyes, situated anteriorly, become effaced as age advances. Ciliary wreath simple and frontal; the long tail-like foot has internal longitudinal muscles. Alimentary canal simple, tubular, contracted; stomach elongated; teeth attached in rows to two jaws situated in the pharyngeal bulb, and two glands, compose the apparatus of nutrition. The visual organs are red when the animalcule is young, and colourless in old age. The ovarium has only a single ovum. The envelope is a viscid, gelatinous, cylindrical sheath (*urceolus*), into which the animalcule can entirely withdraw itself, or which it may quit when a new one is desirable. The attachment to the bottom of the lorica is by the under surface of the end of the foot-like tail.

ŒCISTES *crystallinus.* — Lorica hyaline, viscid, floccose; body crystalline. The structure it is difficult to see. Each jaw has three distinct teeth. The development of the young from the egg is interesting to observe: Ehrenberg saw within the shell two dark points (eyes) near the already developed jaws; and on giving the egg a gentle pressure it burst, and the free young animal came forth (xxv. 361, a full-grown animalcule in the act of unfolding itself; 362, another with its rotary organ expanded). Their sheaths are incrusted, and within may be seen a number of eggs (363, 364 represent them attached to the pectinated leave of the water-violet, as they appear under a shallow pocket magnifier). Length, with tail, 1-36″; without, 1-140″; lorica 1-70″.

Genus CONOCHILUS (XXV. 365-370).—Animalcules social, having conglomerate and contiguous envelopes; each has two permanent eyes. Only one species is known; its description, therefore, will include that of the genus.

Conochilus *Volvox.*—The compound masses white; envelope gelatinous, hyaline, consisting of from ten to forty animalcules united so as to form a sphere, which revolves in swimming, like the *Volvox.* The frontal region of the animalcule is broad, truncated, and surrounded with a wreath of cilia, interrupted at the mouth, which is lateral. On the frontal plane arise four thick conical papillæ, often furnished with an articulated bristle, especially the two anterior, as seen in xxv. 365, 366, and 368. The œsophagus is short and narrow; its head, or bulb, has jaws, with teeth and four muscles; it lies immediately within the mouth. The stomach and rectum are oval. Two spherical glands are observed near the œsophagus, and posteriorly an ovarium, often containing a large ovum, which is expelled near the base of the tail. The ovate or shortly-cylindrical body terminates in a long, thin, and strong cylindrical foot-like tail, the end having a suction-disc. The gelatinous envelope is only perceptible in coloured water, except when infested with green parasitical Monads; the animalcules can completely withdraw themselves within it, their tails becoming thickened and bent. (In the group, xxv. 365–368, the lorica is not shown.) There are no anterior muscles, but three pairs of posterior ones, which disappear near the rotary organ; there are also a back and two lateral pairs. Several transverse bands appear connected with two anterior, lateral, longitudinal ones, which, Ehrenberg states, must arise from a network near the head, as in *Hydatina.* These are probably muscular. He has also seen two spiral bands, situated posteriorly. Two beautiful red visual organs lie immediately beneath the wreath of cilia, and behind them little oval bodies, which he regarded as nervous ganglia, but doubtless erroneously. In the foot-like tail are two large wedge-shaped glands, probably male organs. These creatures will feed upon carmine and indigo, but are mostly filled with a golden-coloured food. (xxv. 370 represents a cluster of animalcules magnified about ten diameters, of which figs. 365-368 represent a portion highly magnified; the first is an under view, the two next dorsal views, and the last a side view. xxv. 369 shows the jaws, teeth, and part of the pharyngeal bulb separate.) Size 1-60″; sphere 1-9″.

FAMILY III.—MEGALOTROCHÆA.

No envelope or lorica. Rotary organ, which is also that of locomotion, simple, incised or flexuose at the margin. Distant muscular bands visible, by means of which the shape of the body can be modified. In *Megalotrocha* the alimentary canal is provided with two jaws, a stomach, two cæca, and two glandular appendages. In *Microcodon* there are two single-toothed jaws, and a simple canal, without distinct stomach or cæca. The ovarium in both genera develope a few large ova, each of which in *Megalotrocha,* Ehrenberg affirms, after expression, is retained in connexion with the body by means of a thread. Water-vascular canals, with tremulous tags, exist in *Megalotrocha*; red eye-spots in both genera indicate a nervous system; and in *Megalotrocha* a radiating body, supposed to be a cerebral ganglion and to form dark glandular (?) spheres, are seen in the neighbourhood of the mouth.

Ehrenberg's divisions of the family are given at p. 478 of the General History.

The genera contained in this family are undescribed by Dujardin and Leydig, whilst Siebold only recognizes *Megalotrocha. Cyphonautes,* instituted by Ehrenberg upon two animalcules found in water from the Baltic, Dujardin considers is a doubtful member of the Rotatorial class; and Leydig suggests that it is probably a larva of some cephalous mollusk. In the propriety of excluding it from amongst the Rotatoria we fully concur. Dujardin and Leydig also transfer *Microcodon* to another family, regarding its caudal process as being a free articulate foot rather than a contractile attached peduncle. Its affinities are unquestionably with *Furcularia*, *Notommata*, and *Hydatina*, rather than with *Megalotrocha*.

Ehrenberg's description of the ovum of *Megalotrocha albo-flavicans* contains some grave errors. He describes the embryo as developing within the germinal vesicle, and growing at the expense of the surrounding yelk, as is the case with a vertebrate ovum. This is so contrary to what occurs in other Rotifera, in which the entire yelk is *directly* transmitted into the embryo, that, merely reasoning from analogy, we should be led to reject it. But Kölliker has shown that the embryo of *Megalotrocha* is developed in the same way as those of other Rotifera.

Genus MICROCODON.—Eye single; wreath of cilia simple, bent in the middle so as to resemble the figure 8 lying transversely; alimentary canal thick and straight, without a stomach; no œsophageal tube, but a sort of pharyngeal bulb and a couple of single-toothed jaws; also a turgid ovarium. Immediately behind the rotary apparatus is a small red visual organ; and at the frontal region, beside it, is a reddish knot whose function is unknown.

MICROCODON *Clavus*. — Campanulate, pedicled, the styliform foot-like tail as long as the body; in the middle of the brow are two bundles of stiff bristles; two pincer-like points, evidently teeth, project out of the middle of the rotary organ, and are in connexion with the reddish jaws. (XXXII. 371 is a back, and fig. 372 a left side view.) 1-280″.

Perty thinks that the so-called eye consists of two red stripes, beneath which a ribbed body is faintly discernible.

Genus MEGALOTROCHA.—Eyes two, sometimes becoming effaced by age; rotary organ has two lappets. The nutritive system consists of a stomach, cæcum, rectum, and œsophageal head, having two jaws, with teeth, and two glands; reproductive organs, a short knotted ovarium, with a few ova; muscles, three pair anterior, two pair posterior, longitudinal; two contractile muscles for the rotary organ, and four œsophageal; eyes frontal, of a red colour when young; four circular transverse muscular bands are also seen. The nature of four opaque white spherical bodies at the base of the rotary organ is unknown.

MEGALOTROCHA *albo-flavicans* (*Vorticella socialis*, M.). — White and free when young; yellowish, and attached in radiating clusters when old. Ehrenberg states he has often perceived the red eyes within the unbroken egg; and the jaws, as if in the act of chewing, move laterally and horizontally against each other. Two ova are rarely produced at one time; the egg, when expelled from the body, remains attached to it by a thread; and the parent has often four or five thus attached, and in process of further development. (XXXII. 374–376 represent different specimens; 377 merely the teeth and jaws separate.) Upon water-plants. Size of single animalcule 1-36″; of the spheres 1-6″ (XXIII. 1).

M. *velata* (Gosse).—Animals separate; disc partially enveloped in a cleft, granular integument; eggs not attached to the parent after deposition. 1-55″.

FAMILY IV.—FLOSCULARIÆA.

Rotatoria surrounded by a case or envelope, and provided with a single rotary organ, flexuose at its margin and lobed or divided, having from two to six clefts. In some genera the cilia of this organ are quiescent at intervals, not vibrating continuously; the alimentary canal is complex, usually divided transversely into several segments, and with various external appendages, believed to be glandular, the proventricular segment, gizzard, or pharyngeal bulb furnished with teeth. *Lacinularia* has a mouth, œsophagus, pharyngeal bulb with teeth, a stomach constricted into three segments, and a short intestine; the lower stomach clothed internally with a very long cilia. *Melicerta* has a similar arrangement, but with only two unequal segments in the stomach, both of which are ciliated interiorly. Two water-vascular canals arise from a contractile sac opening into the cloaca, and pass upwards, one on each side of the alimentary canal to the head, where, in *Lacinularia*, they ramify into a network; along their course they have appended to them small tags or sacs, each containing a large vibratile cilium. These have been seen in *Lacinularia, Melicerta,* and *Stephanoceros*. In *Lacinularia, Limnias,* and *Melicerta*, a small lobate mass exists near the mouth, believed by Huxley to be a cerebral ganglion. Leydig assigns nervous functions to small bodies distributed through *Lacinularia*; but these appear to be merely the small stellate masses of viscid protoplasm described by Williamson in *Melicerta*, and Leydig in *Stephanoceros*. Eyes exist in all the genera, except *Tubicolaria*, at some stage of life. In *Melicerta* and *Lacinularia* they disappear as the animal approaches adult life. Gosse says that the same is usually the case in *Floscularia*, but that he has occasionally met with adult specimens in which eyes were present. Some species (if not all) have well-marked fasciculi of voluntary muscular fibre, especially running parallel to the long axis of the body, which their contraction shortens. Male reproductive organs hitherto unobserved. Female organs an ovisac composed of thin transparent membrane, distended with granular protoplasm, in which are distributed cells or germinal vesicles, each containing a nucleus or germinal spot. In *Melicerta* this ovarium communicates with the cloaca by means of an oviduct. Some species produce two classes of eggs, one being probably the true ovum, the other an encased gemma or bud. Several species retain the eggs within the envelope of the parent until the young are hatched; others set them free at an early stage of embryonic development.

Ehrenberg's arrangement of the genera of this family will be found at p. 478 of the General History.

Eyes present			Tubicolaria.
One eye present (when young)			Stephanoceros.
Two eyes present (when young).	Rotary organ two-parted when full-grown.........	Envelope of the single animalcules distinct or separated...	Limnias. Cephalosiphon.
		Envelope of the single animalcules conglomerated	Lacinularia.
	Rotary organ four-parted when full grown		Melicerta.
	Rotary organ five- to six-parted when full-grown		Floscularia.

Dujardin has a family of "Flosculariens," which, however, differs much from that of Ehrenberg, both in its distinctive characters and in the species assigned to it. The French naturalist includes only two genera, viz. *Floscularia* and *Stephanoceros*. Contrary to Ehrenberg's assertion, these two genera are stated by Dujardin to be destitute of a rotary organ, and indeed of vibratile cilia, and are described as having a campanulate, contractile body, tapering towards the base so as to form a long pedicle, by which they affix themselves to solid bodies. Their mouths are furnished with horny jaws. Speaking of their affinities, he remarks, "The Flosculariens, like the Melicertiens, also have a certain affinity in form with the Vorticelliens and the Stentors, and also with the *Campanulariæ* among polypes. They live in the same way, fixed to water-plants by the pedicle of their campanulate body, the margin of which presents five or six lobes, terminated by appendages or cilia, without, however, any indication of a vibratile movement. At the bottom of this wide opening is situated the mouth, provided with jaws attached to a muscular bulb, less frequent and regular in its movements than the other Rotatoria. In *Floscularia* the jaws are simple, and the lobes of the (anterior) margin short, but with long radiating cilia; whilst in *Stephanoceros* the jaws are compound, and the marginal lobes very long and covered with short cilia." Dujardin states further, that the gelatinous case of *Floscularia* may disappear, and therefore cannot be used as a generic distinction, either in the case of that genus or indeed of the other genera included in Ehrenberg's family of the same name. Entertaining this opinion of the differences of the gelatinous envelope being accidental, not constant, Dujardin rejects the genus *Limnias* as not distinct from *Lacinularia,* whilst he denies that the latter is generically distinct from *Megalotrocha*—a conclusion in which Huxley is disposed to agree with the French naturalist. Of the remaining genera of Ehrenberg's family Floscularicæa, viz. *Tubicolaria, Lacinularia,* and *Melicerta,* to which he adds *Ptygura,* already described, Dujardin constitutes a family which he terms Melicertiens. In some of these objections there is force. *Floscularia* and *Stephanoceros* undoubtedly differ from the remaining genera in the form assumed by ciliated appendages supposed to represent the trochal disk of *Melicerta* and *Lacinularia.* Gosse states that in *Floscularia* rotation is accomplished, not by the tufts of long setæ, but by cilia set on the inner surface of the disk, which cause the currents to converge to the mouth of the animal; hence, if the setigerous bulbs of *Floscularia* and the ciliated arms of *Stephanoceros* are not the homologues of the true trochal disks of *Melicerta,* the propriety of Ehrenberg's definitions is seriously impaired. But we see no reason for rejecting this homology in the case of *Stephanoceros* merely because the motion of the verticillate cilia is periodic and interrupted instead of continuous: and if Mr. Gosse is correct in his conception respecting *Floscularia,* it is equally entitled to its present place; for whilst, on the one hand, it is not essential to a trochal disk that its moving cilia should be arranged at its margin, on the other, these cilia do not exclude the possibility of other appendages, such as the pencils of setæ in *Floscularia,* being attached to the same organ, though such appendages may have no homologues amongst the other Floscularian genera.

Dujardin's objection respecting the gelatinous case of *Floscularia* is probably based on error. Mr. Gosse has shown that in some cases it is so thin that it might easily be overlooked, without great care being taken to discover it.

Leydig of course rejects Ehrenberg's family of Floscularia, arranging the animals composing it in his first group, along with *Œcistes* and *Conochilus,* with which they have unquestionably a very close affinity.

The creatures composing this family are undoubtedly among the most interesting and beautiful of Infusorial animals. Their developed organization, and singular habits, render them objects of the highest interest, both to the naturalist and the physiologist; whilst their exquisitely beautiful contour and the magnificent phenomena presented by the trochal cilia when in active rotation, never fail to impress even the most careless of observers with a sense of wonder and delight.

Genus TUBICOLARIA (XXXII. 379–382). — Figure clavate, with a transparent gelatinous case. Rotary organ deeply fissured on the abdominal aspect, and less strongly on the dorsal side, by which it is divided into two lappets, each of which is again partially subdivided into two. Ciliary wreath double, with a space between the rows. Mouth opening directly into the œsophageal bulb, in front of which is a small vesicular organ filled with pale-reddish matter. Stomach long, with thick cellular walls and four glandular organs surrounding its upper extremity. Intestine thin and clear, curving slightly forward towards the anus. Two water-vascular canals extend along the body, apparently forming a network at the head, and bearing a couple of vibratile tags. No contractile vesicle observed at their cloacal extremity. Foot, by means of which it adheres to foreign bodies, terminated by a bundle of cilia. Two tentacles extend from the abdominal surface, a little below the mouth; each has a clear fibrous-looking tract along its centre, and is terminated by a bundle of setæ. Embryo with the gelatinous sheath colourless, but acquiring consistency and a yellowish hue with advancing age. There is a small concretionary mass, apparently surrounded by a sac, affirmed by some to be urinary, in the body of the embryo.

TUBICOLARIA *Najas.*—The jaws have four teeth; and the tactile tubes are hairy anteriorly. This animal is described fully in the account of the genus; and XXXII. 378–382 will illustrate it. 381 represents the animals of natural size, as found attached to the roots of *Lemna polyrrhiza*, with those of the following genus; fig. 379 represents an animalcule within its case, the rotary organ withdrawn; fig. 380, another extended, and without its lorica; fig. 382, the œsophagus, with the jaws and teeth separate. 1-36″.

Genus STEPHANOCEROS (XXXII. 383; XXXVII. 1–4). — Figure clavate, with five long arms at its anterior extremity, surrounded by verticils of cilia. Sheath without parallel sides and with strong parallel folds or curves; either crystalline without any foreign admixture, or sometimes overspread with small linear bodies like small dead Vibrios or *Microglenæ*. It apparently is not tubular, but a solid gelatinous mass envelopes the animal as high up as the base of the rotary arms. Acetic acid renders it white, and nitric acid renders its outline more clear. Beneath the cuticle is a granular layer containing nucleated cells. The cilia of the arms appear planted in a granular stratum external to the cuticle, from which they are detached in bundles when subjected to slight pressure. A deep transverse fold of the integument exists at the base of the rotary organ, and contraction throws the peduncle into corresponding folds. Between the skin and the viscera are numerous branching corpuscles resembling cells of connective tissue. These cells correspond with what were described by Professor Williamson in *Melicerta ringens.* They look like small globules of ductile protoplasm, and closely resemble the ductile bands seen in *Noctiluca miliaris.* It is not impossible that these may really be some unchanged remains of the protoplasm of the ovum, which they closely resemble. Four long muscles, contained in sarcolemmata or sheaths, proceed from the foot anteriorly, branching dichotomously. Alimentary canal composed of a funnel-like oral cavity, opening into a still wider proventriculus having an intermediate septum and four long bristles with hooked extremities, then a globular maxillary bulb, conducting to a special stomach, which terminates in a short intestine. The oral cavity is lined with fine cilia; and the proventriculus consists of two membranes, not in close contact, but with a narrow intermediate space. The maxillary teeth, the lining of the maxillary bulbs, and the œsophageal bristles resist the action of liquor potassæ, indicating a chitinous composition. The walls of the stomach have a thick layer of large cells filled with yellow granules or fat-corpuscles. Intestine transparent and ciliated internally. A contractile sac connected with the cloaca, from which spring two broad water-vascular canals, which are lost anteriorly in front of a fatty mass surrounding the proventriculus. Ovarium developing but few ova at a time; these, when discharged from the ovary, are still seen to be enclosed in a membranous oviduct, extending from the ovary to the cloaca. No male organ hitherto discovered.

Immediately above the proventriculus is a large collection of hyaline vesicles, which evidently open externally by a short duct. A dark granular vesicle appears at the posterior end of the body of the embryo, as in *Tubicolaria* and *Melicerta*,—supposed by some authors, but without sufficient reason, to be a urinary concretion. Two eye-specks at the opposite extremity of the embryo. Two vibratile spaces also appear simultaneously, the one in front of the other. The vibratile action is active within the anterior one, whilst within the other a few long cilia undulate slowly.

When the embryo is first distinguishable, and separable from the egg, it has a vermiform figure, and is about ·124 millimetres in length. The head, supporting the eyes, is separated from the body by a constriction; its margin is furnished with numerous cilia, the whole being retractile. Within the body and behind the head are several longitudinal stripes of a doubtful nature; and still more posteriorly is a clear space with some long cilia in action, which may represent the alimentary cavity; the maxillary jaws are perceptible, and the posterior extremity furnished with some cilia. On one occasion Leydig met with another form of embryo, which retained the vermiform aspect in its body and foot, but with the former elongated, and terminated by four arms. Two eye-specks present, and a proboscis in front, with two extended tubular processes terminated by cilia. Extremity of the foot devoid of cilia. The maxillæ were fully developed; and, near the sac with the dark granular concretions, ciliary vibration was discernible. Leydig thinks that the dark granules of the sac escape into the cloaca, and regards them as urinary concretions accumulated in the extremity of the intestine. Cohn rejects the idea that they so escape; and we believe him to be correct on this point. The granules are affected by potash, but not by acetic acid.

STEPHANOCEROS *Eichhornii* (XXXII. 383; XXXVII. 1–4).—The case transparent, like glass; rotary organ with five lobes or arms, each furnished with fifteen verticils of cilia; these arms act occasionally as prehensile instruments. As the eggs are detained in the case until the young are hatched, Ehrenberg erroneously considers this creature viviparous. In XXXII. 383, the eye and tags are visible, and over the latter what Ehrenberg calls ganglia. The case is discerned with difficulty, from its very transparent nature, unless indigo is mixed with the water. 1-36″.

S. *glacialis*.—Only one specimen seen without its stem. The five arms not furnished with ciliary whorls, but with single bristles. 1-14‴.

The internal organization of *Stephanoceros* is well illustrated in XXXVII. 1: *b* is the pharyngeal bulb, resting upon a proventriculus or crop *c*, below which is the maxillary bulb *d*, containing the jaws; *e* is the stomach, with its large cells; whilst *f* is the intestine, terminating at the cloaca; *g* is the ovary containing ova; *k* indicates delicate longitudinal muscles, extending down the peduncle; and *t t* the water-vascular canals with their vibratile tags.

In fig. 2 the detached ovary is represented, consisting, as is usual amongst the Rotatoria, of a delicate membranous sac, *f*, prolonged into an oviduct. The contained ova are seen in different stages of development. At *a* is the stroma or granular mass, with its germs; *b* is an ovum in the first stage of fission; at *c* the ovum has undergone several repetitions of the yelk-division; and at *d* is an ovum in which the contour of the embryo is visible. The two eye-spots seen at *d*; and the so-called dark urinary concretion, seen also in embryonic *Melicertæ* and others, at *k*. The real nature of this last object, which is seen only in the embryonic state of these animals, is yet doubtful. Fig. 3 represents a very young *Stephanoceros* a little after its liberation from the ovum; and fig. 4 another immediately after its liberation from its shell. The dorsal aspect of the jaws of the maxillary bulb, according to Mr. Gosse, is represented in XL. 27, and the oblique aspect of the incus in XL. 28.

Genus LIMNIAS (XXXII. 388–392; XXXVI. 2).—Eyes two; case (urceolus) solitary; rotary organ two-lobed when fully grown, being then constricted in the middle; alimentary canal simple, terminating at the base of the foot or tail; stomach, two jaws with teeth, and two glands also present. The ova are deposited within the case, where they are developed; neither male organs nor water-vascular canals discovered; two visual organs indicate sensation: these in the young animalcules are red, and are even visible within the ovum; but in old age the colour disappears, and hence they are not seen. In the middle of the rotary organ, when expanded, are seen four large globules, which Ehrenberg erroneously considers nervous ganglia, or brain.

LIMNIAS *Ceratophylli* (XXXII. 388–392; XXXVI. 2).—Case white at first, afterwards brown or blackish; smooth, but, being viscid, often covered with extraneous particles; its connexion with the animalcule is a voluntary act of the latter; the two red eyes and the jaws may be observed in the ova when developed; by giving the latter a gentle pressure the shell bursts. XXXII. 389 exhibits an animalcule just emerged from the egg, 392; 391 a young specimen, with a rotary organ nearly circular, and two eyes; 390 a full-grown specimen, without its case, fed on indigo—the jaws (each of which has three strong teeth), the ova, and the traces of longitudinal muscles are seen, the wheel is folded up; 388 another, within its case, having the lobed rotary organ expanded. (XXXVI. 2. is more magnified.) Found upon hornwort (*Ceratophyllum*) and other aquatic plants. Length about 1-20″; case 1-40″.

L. *annulatus* (Bailey).—The case is ribbed and semitransparent, and is composed of a linear series of rings. Found in a ditch at Witlingham, near Norwich, on duck weed (Brightwell); and by Dr. Bailey near New York, U.S.

Genus CEPHALOSIPHON.—Rotary organ bilobed; eyes two; sheath single; two frontal horns, including the siphon.

CEPHALOSIPHON *Limnias*.—Sheath membranous, annulate. 1-6‴ to 1-5‴. On *Ceratophyllum*. Berlin, July.

Genus LACINULARIA (XXXVII. 19–25).—Eyes two (in the young state); the cases (urceoli) conglomerate, or grown together; rotary organ two-lobed when full-grown, but nearly circular when young: this organ is the chief instrument of locomotion. Band-like longitudinal muscles exist within the body. Pharyngeal bulb large, with two jaws, and teeth in rows; œsophagus short, narrow; stomach elongated, transversely constricted, and with cæcal (?) appendages; short. The ovarium is situate about the middle of the body, and opens, along with the intestine and the contractile sac of the water-vascular canals, into the cæcum. Visual organs exist in the young state; red in the developed ovum, but becoming darker as they advance to maturity. Globular bodies support the œsophagus on each side; and below the mouth is a small organ, supposed to be the brain.

LACINULARIA *socialis* (*Vorticella socialis* et *flosculosa*, M.) (XXXVII. 19).—Envelope gelatinous, transparent, in which are implanted numerous individual animals, that have unitedly thrown out the gelatinous secretion in which they are imbedded. Body elongated, conical peduncle (XXXVII. 19 *k*) truncated and forming at its posterior extremity a sucker, attaching the animal to the foreign object supporting the entire group. Trochal disc at the anterior extremity of the body, into which it is drawn when at rest (XXXVII. 19 *a*), but expanding into a horseshoe-shape, with a double row of cilia round its margin. Mouth in the notch of the trochal disk. Pharynx leading to a pharyngeal bulb (19 *b*), in which the jaws are planted. These are not stirrup-shaped, as described by Ehrenberg, but composed of four pieces (XXXVII. 20). Œsophagus passing through the bulb reaches the first stomach (19 *c*), into which two cellular appendages, regarded by Ehrenberg as pancreatic, open. Below this is a second dilation (19 *d*), furnished with several short cellular cæca, and still lower a third, more globular segment (19 *e*), also furnished with external cellular cæca, and clothed internally with long cilia. From this a short intestine, according to Huxley, turns upwards and outwards, terminating in a cleft of the integument on the same side as the mouth. This "intestine" is probably the cloaca of other writers. Two water-vascular canals (19 *i*) arise, one on each side of the intestine (cloaca), and ascend on opposite sides of the body towards the head. They divide opposite the pharyngeal bulb, each into three branches, one of these uniting with its fellow, the others terminating as cæca; within these are distributed five pairs of long vibratile cilia. Vacuolar thickenings of the integument exist in several parts of the body. A small ciliated sac is located below the mouth, and still lower is a small organ believed by Prof. Huxley to be the cerebral ganglion. Two eye-spots occur on the trochal disc of the young animal (XXXVII. 11), but they disappear in the adult. No male reproductive organ hitherto discovered. Prof. Huxley's description of the female organs, and the development of the ova, is as follows:—"The ovary consists of a pale, slightly granular mass, of a transversely elongated form (19 *h*), and somewhat bent round the intestine; it is enclosed in a delicate transparent membrane, which is hardly visible in the unaltered state, but becomes very obvious by the action of acetic acid, which contracts the substance of the ovary and throws the membrane into sharp folds."

Pale clear spaces (XXXVII. 7), which sometimes seem to be limited by a distinct membrane, are scattered through the substance of the ovary; and in each of these a pale circular nucleus is contained. The nucleus is more or less opaque, but usually contains from one to three clear spots. These are the germinal vesicles and spots of the future ova. Acetic acid, in contracting the pale substance, groups it round these vesicles, without, however, breaking it up into separate masses. It renders the nuclei more evident.

The ova are developed thus:—One of the vesicles increases in size; and reddish elementary granules appear in the homogeneous substance around it. This accumulation increases until the ovum stands out from the surface of the ovary, but invested by its membrane, which, as the ovum becomes separated, takes the place of a vitelline membrane.

In the meanwhile the germinal vesicle has increased in size; and its nucleus is no longer visible. In the ovum it appears as a clear space; isolated by crushing the ovum, it is a transparent, colourless vesicle. The perfect ova are oval, about 1-10″ in diameter, and are extruded by the parent into the gelatinous connecting substance, where they undergo their development.

The changes that take place after extrusion, or even to some extent within the parent, are—1, the disappearance of the germinal vesicle (as Huxley judged from one or two ova in which he could find none); 2, the total division of the yelk (as described by Kölliker in *Megalotrocha*), until the embryo is a mere mass of cells (XXXVII. 5, 6, 8, 9), from which the various organs of the fœtus are developed.

The youngest fœtuses are about 1-70″ in length. The head abruptly truncated (XXXVII. 10), and separated by a constriction from the body. A sudden narrowing separates the other extremity of the body from the peduncle, which is exceedingly short, and provided with a ciliated cavity (a sort of sucker) at its extremity. The head is nearly circular, seen from above, and presents a central protuberance, in which the eye-spots are situated. The margins of this protuberance are provided with long cilia, which will become the upper circlet of cilia in the adult. In young *Lacinulariæ*

1-30″ in length, the head has become triangular (xxxvii. 11), and thus it gradually takes on the perfect form. The young had previously crept about in the gelatinous investment of the parents; they now begin to "swarm," uniting together by their caudal extremities, and are readily pressed out as free-swimming colonies, resembling in this state the genus *Conochilus* (Huxley). But, besides the ova whose development is thus described, Professor Huxley observed a second class, to which he refers as follows:—"In a fully-grown *Lacinularia* which has produced ova, the ovary, or a large portion of it, begins to assume a blackish tint (xxxvii. 22); the cells, with their nuclei, undergo no change, but a deposit of strongly refracting elementary granules takes place in the pale connecting substance. Every transition may be traced, from the deep black portions to unaltered spots of the ovarium; and pressure always renders the cells with their nuclei visible amongst the granules. The investing membrane of the ovary becomes separated from the dark mass, so as to leave a space; and the outer surface of the mass invests itself with a thick reddish membrane (xxxvii. 24), which is rough, elastic, and reticulated from the presence of many minute apertures. This membrane is soluble in both hot nitric acid and caustic potass. The nuclei and cells, or rather the clear spaces indicating them, are still visible upon pressure, and may be readily seen by bursting the outer coat. By degrees the ephippial ovum becomes lighter, until at last its colour is reddish-brown, like that of ordinary ova; but its contents are now seen to be divided into two masses, hemispherical from mutual contact (f. 21). If this body be now crushed, it will be found that an inner structureless membrane exists within the first-stated membrane, and sends a partition inwards at the line of demarcation of the two masses. The contents are precisely the same as before, viz. nuclei and elementary granules. I was unable to trace the development of these ephippial ova any further."

Professor Huxley thus indicates his belief in the existence of two classes of ova in *Lacinularia*, one of which he thinks probably requires sexual fecundation, whilst the others do not. Cohn believes that the bodies usually termed ova by Huxley and others are not so, but internal gemmæ.

Genus MELICERTA (XXXII. 386, 387; XXXVI. 1; XXXVII. 12–18).—With a case or envelope; solitary; rotary organ simple, with four lobes when expanded; free longitudinal muscles for the contractions of the body; alimentary canal divided into segments, in one of which (the pharyngeal bulb) are complex jaws; mouth situate at the bottom of the cleft between the two larger lobes of the rotary organ; the orifice of the cloaca near the junction of the long peduncle with the body. Male generative organization unknown; believed by Mr. Gosse to be diœcious. Female organs a large ovary filled with granular protoplasm and germinal vesicles, as in the preceding genus, but with a distinct oviduct opening into the cloaca. Two water-vascular canals, arising from a contractile vesicle, ascend towards the head. Two tactile appendages, with setigerous extremities, on each side the head. Two eye-spots in the young animal. Nervous system uncertain.

Melicerta *ringens*.—Case (xxxvi. 1 *d*) conical, granulated, resembling a honey-comb, of a brownish-red colour; it is composed of small lenticular bodies, secreted and deposited by the animalcule; these are agglutinated by a peculiar viscid matter, afterwards hardened in the water. Into this tube the soft crystalline or whitish animalcule can withdraw itself; and when its flower-like wheel-work (1 *a*) is expanded, the vibratile cilia appear to run along the margin of this organ; but, in fact, each single cilium only turns itself upon its base, their aggregate motion causing a little whirlpool in the water, directed towards the mouth, which is situated in the middle of the two large leaflets of the rotary organ; the eyes in the young animal are placed near the two other bent leaflets, which, according to Ehrenberg, are analogous to a cleft upper lip of the dorsal surface: the discharging orifice is on the same side; and therefore the dorsal tail-like portion becomes a ventral member or foot. (xxxii. 386, an animalcule within its case, having the rotary organ contracted; fig. 387, with the trochal disc fully expanded: the case is given in outline only, in order to show the internal structure.) On Lemnæ and other aquatic plants. Length 1-12″; case 1-24″; egg 1-150″.

The pellets forming the case were thought by Ehrenberg and others to be deposited from the cloacal orifice; but, from the careful researches of Mr. Gosse, this appears to be an error (*Trans. Microsc. Soc.* 1851, vol. iii. part. ii. p. 62). That observer points out the existence of a special rotating organ of a cup-like figure (XXXVI. 1 *c*) (the disc seen above), seated immediately above the projecting tube. This organ he saw fill and empty itself "many times in succession, until a goodly array of dark pellets were laid" down irregularly, the animal effecting their distribution by bending its head downward, so as to bring this cup and the margin of its sheath into apposition. "After a certain number were deposited in one part, the animal would suddenly turn itself round in its case and deposit some in another part. It took from two and a half to three and a half minutes to make and deposit a pellet." Coloured particles in the water "are hurled round the margin of the ciliated disc, until they pass off in front through the great sinus between the large petals;" and the atoms, if few, "glide along the facial surface, following the irregularities of the outline with great precision, dash round the projecting chin, and lodge themselves one after another in the little cup-like receptacle beneath," in which again they are whirled round with great rapidity, and prepared into pellets for the building up of the case of the animal.

The internal organization of this animal has been investigated by Professor Williamson. Like *Lacinularia*, the trochal disc is double at its margin, with two rows of rotary cilia, the currents created by which are directed to the mouth and pass off by the ciliated "chin"—a small additional lobe above the ciliated cup of Mr. Gosse. On each side of the trochal head are two hollow processes or "calcars"—the respiratory tubes of Ehrenberg, but which are probably tactile (XXXVII. 17 *d*). These terminate externally in a deltoid body (13), from which projects a pencil of straight setæ. Along the interior of this tube is a delicate muscular band, by which the setigerous extremity can be drawn backwards into the tube (14), and the setæ thus be removed out of danger. The alimentary canal much resembles that of *Lacinularia*. There is a narrow œsophagus conducting downwards to the pharyngeal bulb (figs. 17 *e* and 23), in which are implanted the peculiar jaws: these are complex (f. 26), consisting of equilateral sets of numerous transverse bars, those of each set connected at their peripheral extremities by an arcuate longitudinal one, and at their inner extremities by a double broad longitudinal one prolonged upwards into a long narrow handle or process which meets its fellow of the opposite side at a kind of hinge-like joint. These jaws work upon one another with a crushing motion by means of the above joint,—the upper part of the alimentary canal, and consequently the food swallowed, passing between them. Below the pharyngeal bulb is an oblong stomach, with cellular parietes and lined with cilia. A constriction separates this from a lower and more spherical portion (17 *g*), also cellular and lined with still longer cilia. This opens into a long cloaca (17 *k*), which turns suddenly upwards to its terminal outlet (17 *i*). The interior of the body contains numerous free muscular bands. These are especially distinct in the peduncle, along the entire length of which several of them run, which shorten the body in its axial line. Each fasciculus consists of transversely striped or voluntary muscular fibre, and is enclosed in a sarcolemna or membranous sheath (18). Diffused through the body of the animal, but specially distinct at the upper part of the peduncle, are numerous small masses of viscid granular protoplasmic substance, which send slender prolongations to each other and to the surrounding parts, reminding the observer of the pseudopodia of the Rhizopods and the internal threads of *Noctiluca*.

The water-vascular system consists of two canals arising from a small pyriform contractile vesicle below the stomach, and apparently with the cloaca. One ascends on each side of the alimentary canal towards the head, where they branch. Vibratile tags are connected with them.

Professor Williamson describes the ovary as "a hollow sac (XXXVII. 23 *k*), consisting of a very thin pellucid membrane. It is filled with a viscid granular protoplasm of a light grey colour, in which are distributed from twenty to thirty nuclei, each having a diameter of from 1-1200″ to 1-1600″. Each nucleus contains a large nucleolus, varying in diameter from 1-1600″ to 1-3500″. In its normal state the granular protoplasm is of a uniform grey colour, flowing wh

is ruptured. The nuclei situated nearest the centre of the ovary appear to be successively selected for development. One of these nearest the surface attracts around itself a small portion of the granular protoplasm, detaching it from the remaining contents of the organ, though in close contact with them. The portion thus specially isolated gradually enlarges, assuming at the same time a darker hue, whilst, from its central position, it partially divides the upper from the lower half of the remaining ovarian protoplasm. At the same time the central nucleus sometimes undergoes some slight enlargement, and its nucleolus appears to become absorbed. The position of this nucleus in the centre of the ovum is now indicated by an ill-defined transparent spot; but on bursting the protoplasmic mass, it is seen to be a small spherical cell about 1-1000" in diameter, having very thin pellucid walls and scarcely any visible cell-contents. When the ovum thus segmented from the ovarian protoplasm has attained its full size (XXXVII. 17 *o*), it becomes invested by a thin shell, which is apparently a secretion from its own surface."

"The ovum being now ready for expulsion, it is slowly forced down to the lower part of the ovary, the stomachs being drawn upwards and to one side in order to make way for it. Yielding to the pressure produced by the successive contractions of the body, the ovum sweeps round the inferior border of the lower stomach, and, passing through the dilated oviduct, enters the cloaca. The latter canals become entirely everted, as is the case when the excrements are discharged; and by a sudden contraction the ovum is expelled."

Professor Williamson minutely describes the conversion of the yelk into an embryo — the successive segmentations of the nucleus and surrounding yelk, until the whole becomes a cellular mass, as in *Lacinularia*. The first visible evidence of life is the production of a few moving cilia, especially near the future head, followed first by traces of the dental apparatus, then by the development of the various organs, including the two eye-spots, soon after which the young animal escapes from its shell.

"Almost immediately after its escape from the egg, the young *Melicerta* stretches itself out, and, everting the anterior part of its body, unfolds several small projecting mamillæ (XXXVII. 16), covered with large cilia, by means of which it floats freely away. The ciliated mamillæ at this stage of growth are not unlike those seen in *Notommata clavulata*, but they soon enlarge and become developed into the flabelliform wheel-organs of the matured animal." In this stage all the organs of the perfect animal are present, showing that the creature passes through no larval form, and that it is not identical with the *Ptygura*, as Ehrenberg and others have thought. After swimming about some time, a dark-brown spot disappears from the posterior part of the body, followed by the eye-specks, when, the same writer adds, "the animal attaches itself by the tail to some fixed support, and developes from the skin of the posterior portion of its body a thin hyaline cylinder, the dilated extremity of which is attached to the supporting object. This structure has already been noticed by Dr. Mantell (*Thoughts on Animalcules*), though I have never seen it so largely developed as is represented in his figures. The young animal, having chosen a permanent resting-place, commences the formation of its singular investing case. I have verified Dr. Mantell's account of the position occupied by the first-formed spheres. They are arranged in a ring round the middle of the body (XXXVII. 15), and are for some time unattached to the leaf or stem which supports the animal. They appear to have some internal connexion with the thin membranous cylinder. At first new additions are made to both extremities of the enlarging ring; but the jerking constrictions of the animal at length force the caudal end of the cylinder down upon the leaf, to which it becomes securely cemented by the same viscous secretion as causes the little spheres to cohere." "When the ova are discharged from the cloaca, they successively fall into the cavity of the tessellated case, where they undergo development. I have often found as many as four in one case in various stages of progress. It is whilst the eggs are thus protected that the young animals burst their shells, swimming out at the free extremity of the case as soon as they are liberated."

Genus FLOSCULARIA (XXXII. 384, 385; and woodcuts).—These creatures possess when young two eye-spots. Several lobes surround the head, each surmounted by a pencil of long setæ. These lobes are regarded by Ehrenberg as the rotary organ; but, according to Gosse, the upper surface of the central disc fulfils the rotatory functions. Body furnished with a long peduncle, by which the animal is fixed, and the whole surrounded by a thin diaphanous case resembling that seen in the *very young Melicerta.* From its transparency this can often be detected only by colouring the water with some pigment. Alimentary canal simple, conical. Reproductive system resembling that of *Lacinularia.* Ova deposited within the case. When viewed from above, the head of the animal resembles an *Acineta.*

FLOSCULARIA *proboscidea.*—Case cylindrical, hyaline, gelatinous. Setigerous lobes six, with short cilia surrounding a ciliated flexible proboscis, which appears to have an opening at its extremity. Dujardin thinks this proboscis may be nothing more than one of the ciliated lobes advanced towards the centre. Body ovate, with a long styliform peduncle attached to the base of the case; when extended, the body and part of the foot are protruded. Found upon the leaves of *Hottonia palustris.* Length when extended 1-18″; case 1-36″.

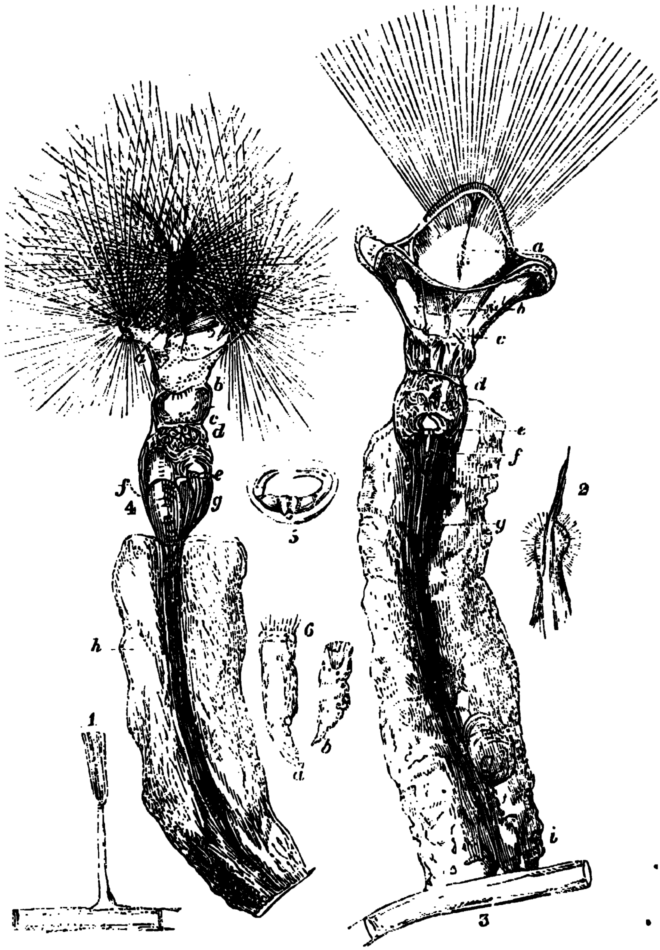
F. *ornata* (*Cercaria*, M.) (XXXII. 384, 385).—Case or envelope hyaline; very thin at its upper extremity; thicker, and often with foreign bodies entangled in it inferiorly. It is sometimes very sluggish, but at others moves with considerable activity, often contracting itself very quickly within its case. The setigerous lobes, according to Gosse, are not the true rotatory organs: "yet," he says, "there is a rotatory organ — the particles of floating matter revolving in a perpendicular oval within the mouth of the disc. Hence I conclude that the rotatory cilia are set on the inner surface of the disc." He further adds: "When the pencil of united tufts is in process of expansion the hairs have a wavy, quivering sort of motion, but when expanded they remain perfectly motionless. The two red eyes seen in the young animal ordinarily disappear in the adult; but Mr. Gosse has occasionally met with such specimens in which they were still plainly visible. He has observed the body "to be lined with a yellowish vascular membrane, which does not extend up to the petals, but terminates at the neck with a free, very mobile edge, forming an irregular opening, the outline of which is constantly changing by the contraction and expansion of the membrane. The opacity of this lining renders it difficult to resolve the viscera." "Ehrenberg speaks of an œsophageal head above the jaws; but I can see nothing of the kind, and am inclined to think he may have mistaken the ever-contracting opening of the lining membrane for one." These animals are very fond of *Chlamidomonas*; and when swallowing large bodies, such as *Naviculæ*, they contract the entire body. Ehrenberg has numbered as many as five ova retained within the diaphanous case at the same time. Gosse once counted nine. These, as is also the case in *Melicerta*, are generally in different stages of development, — in some the perfectly-formed embryo being distinctly visible, its movements and its two red eyes being very manifest. With a moderate pressure Ehrenberg burst the shell, which, according to Gosse, is calcareous: the young animal crawled out with a slight vibratory motion; the cilia were short and not very distinct. In the mature animal the peduncle is truncate at its extremity. Upon *Ceratophyllum* and similar plants. 1-108″. In XL. 25 the dorsal aspect of the jaws is represented, and in 26 their frontal aspect.

Dr. Dobie writes (*A. N. H.* Oct. 1849): "Ehrenberg regards the *Floscularia* described and figured by M. Peltier, as identical with his *F. ornata.* Both Dujardin and Peltier found the rotary organ five-lobed in the species observed in France; so we must either hold with Pritchard that *F. ornata* has sometimes five, at others six lobes, or consider the five-lobed species a variety of *F. ornata.* .... My friend Mr. Hallet writes me that he finds *F. ornata* with a six-lobed rotary organ and no process."

The two next species and accompanying remarks are taken from a paper by Dr. W. M. Dobie (*A. N. H.* Oct. 1849).

F. *campanulata.* — Case diaphanous, rotary organ with five flattened lobes, fringed with very long cilia; body ovate, without proboscis; tail long, and terminating abruptly in a transparent filament, spread out in a kind of sucker at the point of attachment. Length 1-50″ when extended. Egg with two red eye-spots; contained in a large ovary. Found near Chester, on *Ceratophyllum* and Confervæ.

F. *cornuta*.—Case short, diaphanous, not very distinct; rotary organ furnished with five rounded lobes, surrounded by extremely long and delicate cilia: a short, narrow, non-ciliated, flexible process (cornu) is attached to the outside of one of the lobes. Egg with two red eye-spots; young animal with vibratile cilia on the head, and rapidly locomotive. Length 1-40″ when extended. In same locality as the preceding (see woodcuts).



Floscularia cornuta, Dobie.

The lobes of the rotary organ of *F. cornuta* resemble very much those of *F. ornata*, but only five exist, while in the other there are six. According to Ehrenberg the *F. campanulata* is gregarious, whilst *F. cornuta* is solitary; the former is also stronger and is more active than the latter.

Leydig has described a *Floscularia* under the name of *F. appendiculata* (*Zeitschrift für wissenschaftliche Zoologie*, July 1854). Mr. Gosse, however, believes this to be identical with the *F. cornuta* of Dr. Dobie.

FAMILY V.—HYDATINÆA.

Illoricated Rotifera, having the ciliated wreath divided into several lobes or subdivisions.

In many of the genera distinct striated muscles of the voluntary type exist, effecting the various movements and altering the form of the body. The nutritive system usually consists of a simple conical alimentary canal without a distinctly separated stomach (Cœlogastrica); but a pyloric constriction exists in *Hydatina*, some *Notommatæ*, and other forms. *Notommata clavulata* and *Diglena lacustris* have special cæca appended to their stomachs. Variously modified cellular appendages, supposed to be glandular, exist in all the genera. The ovarium is mostly ovate and only evolves a few ova at a time. In *Notommata Myrmeleo*, *N. clavulata*, and *Diglena lacustris* it is very long. In all it communicates with the cloaca, by an oviduct of varying length. The ova vary considerably, and belong to two distinct types, respectively termed the summer and winter ova. The former have a smooth shell, and are generally regarded as mere unimpregnated gemmæ, like those of Aphides amongst insects. The latter are hard, and often spinous, in which form M. Tarpin regards them as constituting the genera *Bursella* and *Erithrinella* (?) amongst plants. It is amongst the members of this group that many of the interesting researches of Dalrymple and others have been made, demonstrating the existence of diœcious animals. Amongst the Rotifera the male animals of *Hydatina* and *Asplanchna* are distinct from the females. They are generally characterized by their smaller size and by the absence of digestive organs—indicating a brief existence, during which the *vis vitæ* derived from the ovum suffices to sustain the animals in fulfiling their several functions. According to Cohn, this absence of an alimentary canal in the males does not characterize the male of *Notommata parasitica* (XXXIX. 8); but this is so exceptional to all other allied discoveries as to suggest a doubt of its correctness: at the same time, we have scarcely crossed the threshold of this inquiry, and want the materials for general conclusions. Water-vascular canals, variously modified, exist in most of the Hydatinæa. The frequent association of the red "eye-spots" with a subjacent organ, supposed to be a cerebral ganglion, suggests sensational functions; but no true nerves occur.

Some species of *Synchæta* are said to evolve light and contribute to the phosphorescence of the sea. *Hydatina senta*, *Diglena catellina*, and *Triarthra* are sometimes so numerous as to render the pools in which they reside milky and turbid.

Ehrenberg's classification of this family is given at p. 478, Section Sorotrocha, Division Polytrocha.

The first genus (ENTEROPLEA), established to receive *E. hyalina*, has been shown by Leydig to have no existence, as the above animalcule proves to be the male of *Hydatina senta*.

Genus HYDATINA (XXXII. 394; XL. 1, 2).—Eyes absent. The female has two jaws, consisting of several teeth and a forked foot. Locomotion is effected by the compound wheel organ and the pincer-like foot, acted upon by complex internal muscles. In *Hydatina senta* the sexes are distinct, the *Enteroplea hyalina* being the male form.

HYDATINA *senta* (*Vorticella senta*, M.) (XXXII. 394; XL. 1).—Body of the female conical, hyaline; rotary organ consisting of a simple external wreath of cilia surrounding the truncate anterior extremity of the body, and enclosing at the back part of the head an interrupted row of tufts of cilia supported on small hemispherical projections,—the cilia of the latter broader and longer than those of the external row. Within these is a third uninterrupted line of cilia. Neck constricted and thrown into folds or wrinkles by transverse filamentous muscles, hung like hoops within the integument, to which Cohn believes them attached only by a few interrupted points. These muscles were regarded by Ehrenberg as vessels. The contractile influence of these and similar muscles occupying the lower parts of the body is antagonized, according to Leydig, by the elasticity of the cuticle, but according to Cohn by the pressure of the compressed fluids of the body. Longitudinal contraction of the body effected by numerous muscles proceeding from the head backwards to the centre of both sides of the body and thence to the foot. Ehrenberg counted nine, which number Cohn regards as correct. The latter observed vacuoles and what appeared to be nuclei in the substance of the muscles, but no transverse striæ. Two bodies at the base of the toes Ehrenberg regarded as muscles moving those organs; but Cohn believes them to be glandular, secreting an adhesive fluid by which the creature attaches itself to other bodies.

Digestive canal consisting of an oral orifice (XL. 1 *a*), buccal cavity, pharyngeal bulb (1 *c*), œsophagus (1 *d*), stomach (1 *e*), intestine terminated by a cloacal orifice at 1 *f*, and gastric glands. The buccal cavity a short passage from the mouth (1 *a*) (located on one side of the head) to the pharynx (1 *c*), which is large; and, according to Cohn, a muscular mass invests the jaws, which are complex and not easily interpreted, but consist of several parallel teeth (XXXVIII. 34) arranged in two sets and attached to a complicated pyriform organ: respecting the details of their form, authors differ. A constricted passage (1 *d*) conducts from the pharynx to the stomach (1 *e*), which is large and oblong; its walls are sacculated, or expanded into numerous lateral pouches or pockets opening into the cavity of the stomach, the whole lined by delicate cilia (XL. 4). A narrow pylorus separates this organ from a short conical intestine, the narrow extremity of which terminates at the cloaca (1 *f*), opening near the posterior extremity of the body on the opposite side to that on which the mouth is situated; two large pyriform bodies, supposed to be glandular, are suspended by narrow peduncles on each side of the pharynx.

Connected with the cloaca is a large contractile vesicle (1 *g*), from which ascend two water-vascular canals (1 *i*), convoluted at intervals and giving off small twigs which support tremulous tags (XL. 5). Ovarium a large pyriform sac (1 *h*), connected with the cloaca by a narrow oviduct; it consists of a thin membrane distended by a granular fluid, in which are seen numerous germinal spots. A small body, supposed to be a cerebral ganglion (1 *k*), is situated on one side of the œsophagus, and is connected with a small setigerous groove on one side of the neck by what Cohn believes to be nerves. Male: The *Enteroplea hydatina* (XXXII. 393; XL. 2) of Ehrenberg has been demonstrated by recent researches to be the male of *Hydatina senta*. Like that of many other species it has no visible digestive cavity: in general form it closely resembles the female, but is much smaller. Its reproductive organs consist of a retractile penis (XL. 6 *a*), enclosed in a fold of the cuticle (6 *d*), the opening of which corresponds with that of the cloaca in the female; the base of the penis is surrounded by a gland (6 *b*), above which is the large oblong testicle containing spermatozoa, by the side of which, at its lower part, are two small vesicles (6 *c*), connected with the penis, and filled with numerous large granules. XL. 3 represents an immature ovum of *Hydatina senta*, and fig. 7 the detached spermatozoa from the male animal.

In most cases the female fixes itself to a spot by its foot, and lays several eggs upon the same place, one after another, by sudden contractions; sometimes, when it is going to lay more eggs, it returns to the original spot. In eleven hours after the eggs were laid, vibration of the anterior cilia was observed, by Ehrenberg, within them; and in twenty-four hours the young escaped from the shell. Many of the ova are said to have a double shell, and leave a bright space between the two at one of the extremities; similar ova are found in other Rotatoria, having different shapes. In these double-shelled ova the young are slowly developed. Ehrenberg names them "lasting eggs, or winter eggs." XXXII. 394 represents an animal completely unfolded, seen from the ventral surface. The arrows in the alimentary canal indicate a decussating or circulating movement of its contents, produced by delicate internal cilia, and must not be mistaken for the motion of Monads.

H. *brachydactyla*.— Cylindrical, truncated anteriorly, and suddenly attenuated at the base of the foot; claws short. On *Hottonia*, &c. 1-144''.

Dujardin would include in the genus *Hydatina* several Rotatoria distributed by Ehrenberg among other genera. He says: "Notwithstanding the presence of a red eye-speck, we must consider as Hydatinæ—1. *Notommata tuba*; 2. *N. brachionus*; 3. *N. tripus*; 4. *N. clavulata*," and, though doubtfully, *N. saccigera*, for this species in form resembles a true *Furcularia*. "The *Synchætæ* (Ehr.), characterized by their stiff setæ or styles, are true Hydatinæ from their conical or campanulate form, if their jaws are really pectinated; but if not, they will constitute a genus apart.....The *Distemma maximum*, represented by Ehrenberg with pectinated jaws, and placed as doubtful by him in the genus *Distemma*, characterized by a double eye-speck, appears to be a true *Hydatina*."

Genus PLEUROTROCHA (XXXII. 395, 396).—These have no eyes, but possess a single tooth in each jaw, and a furcate foot. The rotary organ consists, not of a simple wreath of cilia, but of cilia distributed in bundles near each other, the bundles being planted in muscular cases. In *P. gibba* there are two muscles for moving the foot; and in all the species the globular œsophageal head has four, acting upon two single-toothed jaws (fig. 396); œsophagus short; alimentary canal simple, conical, having anteriorly two spherical glands. The anus is at the base of the foot, upon the dorsal surface. The ovary is globular. In *P. leptura* a contractile vesicle is seen. Organs of sensation are not satisfactorily known, and the nervous loop in the neck of the *Hydatina* appears wanting. This genus is not admitted by Dujardin.

PLEUROTROCHA *gibba*. — Truncated anteriorly, enlarging from the front towards the base of the foot, where it is suddenly attenuated, the toes, or claws, short and turgid; near the mouth is a beak-like projection, forming an under lip. XXXII. 395 is a right side view; 396 the teeth and œsophageal head dissected out. Found with *Hydatina brachydactyla*. 1-216".

P. *constricta*. — Elongated, conical, head separated by a stricture; front oblique; toes straight and slender. This animalcule is very active and powerful. Upon *Ceratophyllum*. 1-144".

P. *leptura*.—Body turgid in centre, front oblique; foot slender; toes thin, slightly curved. Amongst Confervæ. 1-144".

P. *renalis* (Ehr.).—Elongate, slightly constricted in front, toes short, frontal portion rather oblique, truncate, pancreatic glands kidney-shaped (reniform). 1-240". Berlin.

P. *truncata* (Gosse).—Subcylindrical; truncate behind above the foot; toes short, straight, slender. 1-175".

Genus FURCULARIA (XXXIII. 397, 398).—Frontal eye single; foot forked. Rotary organ compound. Longitudinal muscles exist in *F. gibba*, and foot-muscles in three species. The œsophagus is very short, its head has two jaws, single-toothed (Monogomphia) in two species, but not in the others; alimentary canal simple (Cœlogastrica), conical, with two ear-like glands; ovary distinct, except in *F. gibba*, which has only a contractile vesicle. Vessels, respiratory tubes, gills, &c., are not recognizable. The eye in *F. Reinhardtii* is placed upon a brain-like mass.

Dujardin has the following remarks on the genus *Furcularia*:—"The genus *Furcularia*, one of the most numerous, undoubtedly requires to be divided after new observations, but not according to the number and disposition of the red points, as has been done by Ehrenberg. This author has indeed distributed some *Systolides*, which appear to us to have the closest relations in form and mode of living, into eight genera" (viz. *Pleurotrocha*, *Furcularia*, *Notommata*, *Scaridium*, *Diglena*, *Distemma*, *Eosphorus*, and *Theorus*); "but many of these are purely nominal, and require a rigid revision.

"The following are the principal species to be classed with certainty among the *Furculariæ*:—1. *F. furcata*=*Diglena caudata* (Ehr.), *Diglena capitata*, and *Furcularia gracilis*; 2. *F. marina*, of the same size and form as the preceding, but marine, and distinguished further by the styles of its tail, which are twice as short, and by its three-toothed but acute jaws, resembling a hook; 3. *F. forcipata*, placed by Ehrenberg among the *Diglenæ*; 4. *F. grandis*=*Diglena grandis* (Ehr.); 5. *F. forficula*, with which must also be associated *Distemma forficula*; 6. *F. canicula*, which Ehrenberg with doubt refers to *Diglena? aurita*; 7. *F. najas*, to which belong the various *Systolides*, more or less like *Hydatina* in their club-shaped form and articulated tail, such as *Notommata petromyzon*, *N. najas*, *N. gibba*, and probably also *Eosphora najas*, *E. digitata*, and *E. elongata* (Ehr.). We moreover refer provisionally to the genus *Furcularia* several other *Systolides* considerably dissimilar in form, some being very long, with two very long styles, of which Ehrenberg makes his *Notommata longiseta*, and *N. æqualis*, and his genus *Scaridium*; whilst others have an ovoid, thick body, rounded posteriorly, truncate in front, and with a short oblique tail, which Ehrenberg calls *Notommata myrmeleo* and *N. syrinx*.

"All these *Furculariæ*, except *F. marina*, to which *F. Reinhardtii* of Ehrenberg must probably be added, have been found in fresh water; but it is most likely the number of those living in the sea are much more numerous; and I have indeed myself met with three or four distinct species, which I have from want of time not yet described."

FURCULARIA *gibba*.—Oblong, slightly compressed, under side flat, back convex, toes forked, long (styliform), equal to half the body; the eye is placed upon a nervous ganglion over the mouth, clearly indicating the dorsal surface; the ovarium has generally one large and ripe ovum. The movement of this animalcule is somewhat slow. Found in green water, and amongst Confervæ. 1-69″.

F. *Reinhardtii*.—Fusiform, truncated in front; foot elongated, cylindrical, and shortly furcate at the end; a slight stricture divides the body and head. XXXIII. 397 represents an animal extended, and 398 another, contracted; the former is a side (right), the latter a back view. Parasitic upon *Monopyxis* (*Sertularia*) *geniculata*, in sea-water. 1-120″.

F. *Forficula*.—Cylindrical, obtusely pointed in front, rounded and dentated at the base, on the upper side; the toes very long; the rotary organ appears to have two frontal clusters of cilia near the eye, and a wheel-like bundle on each side. 1-144″.

F. *gracilis*.—Slender, cylindrical, suddenly attenuated at the base of the furcate foot; toes straight, long, but shorter than half the body. The rotary organ appears disposed on six muscular masses.

F. *cæca* (Gosse).—Cylindrical; eye wanting, or not discernible; toes slender, obtuse. Length, including toes, 1-135″. Leamington.

Genus MONOCERCA (XXXIII. 399–417).—Eye single, seated upon a ganglionic mass, cervical; foot simple, styliform, resembling a tail. In two species the vibratile cilia are distributed into about six bundles, their band-like longitudinal muscles and those of the foot producing locomotion; the sides of the œsophageal head are unequal, as also the two jaws, which have one or two teeth; the œsophageal tube is curved and long, and the simple alimentary canal conical, with two ear-like glands anteriorly. An ovary and a contractile vesicle are evident. In two species a tube projects from the frontal region.

MONOCERCA *Rattus* (*Trichoda Rattus*, M.; *Rattulus carinatus*, Duj.).—Ovate, oblong, truncated anteriorly, and unarmed; foot styliform, the length of the body. This creature swims slowly, in a stiff manner; when stationary it throws the styliform foot backwards and forwards. The ovary has a reddish colour; behind it lies a roundish contractile vesicle. The foot has a short base, with a cordate internal muscle, and four unequal bristles. Amongst Confervæ, &c. 1-120″.

Mastigocerca carinata is regarded by Perty and Dujardin as identical with *Monocerca Rattus.* Dujardin identifies with this an animal he discovered and figured (XXXVIII. 22), measuring 0·147 millim., or with its tail 0·29 millim.

M. *bicornis.*—Ovate, oblong, truncated in front, armed with two spines; foot styliform, a little shorter than the body; the oblique œsophageal head exhibits delicate transverse corrugations; it has a bent and a straight jaw, with probably three teeth in each. (XXXIII. 399, an animal seen on its right side; 417 another, contracted, and having its rat-like tail bent.) 1-72″.

M. (?) *valga* (*Vorticella valga,* M.).—Small, almost cubical, with distinct head, an elevation on the back, and a conical foot unequally forked; the rotary organ, during contraction, shows four muscular sheaths; and the distinct red eye is placed upon a less distinct ganglion; the œsophageal head is not evident. 1-288″.

M. *brachyura* (Gosse).—Form that of *M. Rattus*, but the foot short (one-fourth of total length), slightly curved, and horizontally flattened; a large eye in the occiput, *and another small one in the breast.* Length, including foot, 1-135″.

M. *Porcellus.*—Thick and plump; foot short, much curved and bent under the body, dilated, flattened horizontally, and carrying a smaller spine beneath it as in a sheath; front and chin each armed with a short sharp spine. Length, including foot, 1-110″.

M. *stylata.*—Short, irregularly oval; foot a nearly straight spine, less than one-third of total length; eye large, red, set like a wart on the back of the occipital sac; forehead conical, pointed. Length, including foot, 1-170″.

Genus NOTOMMATA (XXXIII. 416–421; XXXVI. 3–6; XXXVII. 27–32; XXXVIII. 26; XXXIX. 8, 9).—These have, according to Ehrenberg, a single eye upon the neck, and a bisulcate foot, resembling a forked tail. The rotary organ compound, its cilia forming bundles on the frontal region. Eight of the larger species have numerous muscles. Of Ehrenberg's species eighteen or nineteen have two jaws, each furnished with a single tooth; in eight the jaws have many teeth. The œsophagus is mostly short, with a simple wide conical alimentary canal (Cœlogastrica); in *N. tuba* only is there a stomach-like division, with a constriction (Gasterodela); and in *N. Myrmeleo*, *N. Syrinx*, and *N. clavulata* there is also a stomach-like enlarged place, but no constriction (Gasterodela): cæcal appendages are observed only in *N. clavulata.* The two ear-like anterior appendages of the alimentary canal, regarded by Ehrenberg as pancreatic glands, exist in twenty-four species. *N. Syrinx* alone was observed by Ehrenberg to contain fully-developed ova. The water-vascular system is represented in ten species by delicate tubes, with flexible and tremulous gills; only three of the smaller species have gills. In *N. Myrmeleo* and *N. Syrinx* a broad vascular network is distinct about the head. A prominent tactile tube in the neck is present in four or five species; in some others an opening alone is seen. The visual point is red, except in *N. Felis,* where it is colourless; a ganglion is placed beneath the eye in twenty-six species. In *N. Copeus* and *N. centrura* the brain (?) is three-lobed, and placed over the œsophageal head; in the rest it consists of one or more nervous ganglia, situated amongst the ciliary muscles of the frontal region. This genus is especially remarkable for the parasitical habits of its members. They live upon other Rotatoria, upon the Polygastric Infusoria, and even within the globular masses of *Volvox Globator*; "but," says Ehrenberg, "not like a cuckoo's egg in a hedgesparrow's nest, but like the bear and the bee-hive, or a bird's nest in a wasp's nest."

Dujardin has the following criticisms on this genus:—"Five of the species appear to be *Hydatinæ*; nine others, more or less distinct, are, in our opinion, *Furculariæ*; three others *Plagiognathi*; some are imperfectly known; and only six, at most, offer sufficiently precise characters to retain the name *Notommata.* Such are, 1. *N. copeus,* 2. *N. centrura,* 3. *N. brachyota,* 4. *N.*

collaris, 5. *N. aurita*, and 6. *N. ansata*." To these species must be added a seventh, called by Ehrenberg *Cycloglena Lupus*, and an eighth, which we distinguish as *Notommata vermicularis*.

All the best observers agree that the genus *Notommata* requires division, being a very defective one, and containing the elements of several genera; but all the species now composing it must be subjected to a very careful and individual examination before such a division can be made. Until this is accomplished we retain the genus as adopted by Ehrenberg, observing that the analysis of Ehrenberg's views respecting it, as given in a preceding page, will ultimately require many modifications. Some species have already been carefully investigated by Gosse, Perty, and Leydig.

a. *Subgenus* LABIDODON.—*One tooth in each jaw.*

NOTOMMATA *Myrmeleo*.—Body large, bell-shaped; foot short, lateral; teeth curved in a circular forceps-like manner (XXXIII. 420). There are two varieties: in the one (var. *a*), a long thin œsophagus, a globular thick stomach, and a long rectum constitute the alimentary organs. Ehrenberg, by pressure, made an animalcule, whose dark stomach nearly filled the body, disgorge two large specimens of *Lynceus minutus* (described and figured in the *Microscopic Cabinet*); the animalcule afterwards vibrated away in a lively manner. Five transverse muscular bands and four longitudinal ones (a pair uniting to each of the first two transverse ones) represent a muscular system in this variety. In the other (var. *b*), a distinct muscular network is seen at the head, but only four transverse bands and two longitudinal ones going to the first. The red eye is much larger in this variety. (XXXIII. 418, a side view of the variety *b*: to exhibit its organization, a small Crustacean is shown within its stomach. Fig. 420, the manducatory organs separated; fig. 419, the upper part of an animalcule, var. *a*, showing the smaller eye, rotary organs, teeth, and network.) Found in clear water, in turf-hollows. 1-40″.

Notommata Myrmeleo, var. *multiceps*, according to Leydig, presents the following features:—The foot, which on a profile view appears given off from a lateral surface, projects from the abdominal one. The rotary organ not consisting of separate portions, but forming a continuous wreath, which descends towards the mouth, forming an apparent fissure. On the free surface are four unsymmetrical lobes bearing larger setiform cilia. Cuticle soft and thin, slightly acted on by acid, which renders it clearer; subjacent layer granular and homogeneous. Maxillary head very large. Œsophagus long, thin, folded longitutinally. Stomach round, with ciliated cells: no rectum beyond the stomach, Ehrenberg being in error on this point; débris rejected by the mouth. A respiratory canal proceeds from each side the contractile sac towards the head, being much convoluted and enveloped with cell-like corpuscles; a second smaller pair follows a similar course, joining the larger near the maxillary bulb. The smaller have not granular walls, but support numerous tags, which are absent from the larger canals. Two bands proceed backwards from the cerebral ganglion to a couple of fossæ on the dorsal surface, furnished with a bundle of setæ. Eyespeck dark-red or black. Ovary presenting two horns, forming an organ like a horseshoe, the oviduct opening at the base of the tail. Winter ova spherical, bristly, with a light cortical layer containing clear vesicles.

N. *Syrinx*.—Large, bell-shaped; lateral foot scarcely visible; teeth curved and bifid at the points. This species is very similar to the former, and only distinguished from it by its small foot and by the spaces within the cilia-cluster (mouth) being convex, not concave. Found in a turf-pool. 1-40″.

N. *hyptopus*.—Bell-shaped, nearly globular, rather large; foot slightly prominent at the middle, teeth small; vibratile organ composed of four or five muscular bundles; œsophagus very short. 1-72″.

N. *parasita* (XXXIX. 9).—Small, oval; foot short, teeth small; rotary apparatus three or four lobes; œsophageal head globose; œsophagus short; alimentary canal stout, simple, usually filled with green matter. This curious animalcule lives in the globes of *Volvox Globator*, where it deposits its eggs, which are therein hatched; and when of proper age, the creatures eat their way out through the hollow sphere. Summer ova large, smooth; winter ova spinous. 1-40''.

According to Cohn, the male of this species (XXXIX. 8) is a small Rotifer 1-20''' in length. Body short and saccular; two short toes, usually retracted; head distinguished by a slight excavation, and with an ear-like lappet on either side; rotary organ furnished with some stout uncini, in addition to the fine cilia; pharynx cylindrical, containing two scalpel-like teeth, which can be extended beyond the mouth; stomach separated from the intestine by a constriction. A contractile vesicle above the foot, but water-canals scarcely visible. A cerebral ganglion, resembling a long sac, within the head, and bearing a red speck at its anterior extremity. Males and females usually existing in the same *Volvox*. We have considerable doubts respecting the correctness of the above account, since it differs so widely from what has elsewhere been observed amongst such male animals as have hitherto been discovered amongst the Rotifera. The absence of a complete alimentary canal has hitherto characterized all male Rotifera. (The female is represented after Cohn in XXXIX. 9.)

N. *petromyzon*. — Elongated, attenuated at both ends; mouth and rotary organ lateral. Ehrenberg says, in May 1835 he found one in a *Volvox Globator*, whose gemmiferous masses it eats like *N. parasitica*. The eggs are often deposited on *Epistylis*. 1-180'' to 1-144''.

N. *lacinulata* (*Vorticella auriculata* et *aricnulata*, M.). — Small, conical, truncated and slightly lobed in front; teeth extended, often bicuspid. Alimentary canal, according to Leydig, clearly separable into a greenish yellow stomach and a clear intestine. This species is very active. Found with *Chlamidomonas Pulvisculus* in clear water, also in water-tubs. 1-280''.

N. *forcipata*.—Small, elongated; toes long, and often crossed; eye very large. The vibratile organ appears sometimes like a simple wreath. Amongst Lemnæ. Very common in Switzerland, according to Perty, but with a small red eye-speck instead of a large pale one, as described by Ehrenberg. 1-180''.

N. *collaris*.—Elongated, large, gradually attenuated at both ends; neck turgid; toes short. It swims slowly, the vibratile organ being small in comparison with the body. 1-48''.

N. *Werneckii*. — Elongated, gradually attenuated at both ends; toes short. It has two setæ near the mouth. This animalcule resembles *N. collaris*, but is smaller, and lives in the club-like excrescences of *Vaucheria* as an entophyte. 1-90''.

N. *Najas*.—Conical, cylindrical, stout, truncated in front; no auricles. It resembles *Hydatina senta* and *Eosphora Najas*; it is distinguished from the first by its cervical eye, from the latter by the want of frontal eyes. Amongst Lemnæ. 1-120''.

N. *aurita* (XXXVI. 3-6).—Described by Mr. Gosse as cylindrical, but frequently pyriform. Head obliquely truncate, belly nearly straight, posterior extremity produced into a retractile foot (XXXVI. 4 *h*) with two pointed toes, which organ, being anterior to the cloaca, is not a tail. An oval mark on each side of the head, from which the animal can suddenly project a semiglobular lobe by evolution of the integument (XXXVI. 4 *a*), each lobe fringed with cilia, forming a locomotive organ; fringe of cilia extending across the front of the face as far as the constriction of the neck. Maxillary bulb or gizzard (4 *b*) large, oval, nearer the ventral than the dorsal side, having imbedded within it a pair of complex jaws (XXXVI. 6 *). A duct leads from the maxillary bulb to the continuation of the alimentary canal, which is wide, subcylindrical, tapering towards the anus, not divided by any constriction, but at once stomach and intestine; walls thick, probably cellular. Cloaca between the projecting point (XXXVI. 3) and the foot. Ovary large, occupying the ventral region; sometimes long and clear, containing transparent globules (4 *f*), at others granulated (XXXVI. 3). A large developed egg (4 *o*) often occupying a great portion of the abdominal cavity. Eggs large, covered with short flexible spines. Male unknown. Water-vascular system consisting of two sets of tortuous vessels, commencing at the cloaca (6 *a*) and terminating at the head, and bearing tremulous tags. Parallel with the œsophageal bulb, but nearer the dorsal surface, is a large lobulated subglobose mass of dense matter (4 *g*), white by reflected light, but opaque and hence appearing black by transmitted light, occupying the bottom of a deep cylindrical sac. A tube runs through the centre of this sac towards the rotary organ, "on which it opens, or at least impinges" (Leydig). As this opaque mass supports the eye-spot, Gosse regards it as cerebral. Muscular system complex (xxxvi. 5, 6). Six or seven muscles are circular and transverse (6 *t*); others, arranged longitudinally (5 *l*), are attached to various internal viscera and to the integument. Some go to the occipital sac, others to the gizzard and to the foot, effecting various motions in all these organs. Gosse observes, "It commonly keeps the ear-like lobes concealed whilst crawling, but will often suddenly protrude them, and in the same instant shoot off through the water with considerable rapidity and with a smooth gliding motion, partially revolving on the longitudinal axis as it proceeds."

Leydig observes that the alimentary canal consists of two portions—stomach and intestine. 1-70″. Amongst Confervæ, &c.; also beneath ice. (xxxvi. 3-7.)

N. *gibba.*—Back swollen, front truncated, not auricled, no cerebral sacculi below the eye; toes short; the vibratile organs compound. In old exposed infusions. 1-200″.

N. *ansata* (*Vorticella aurita,* M.).—Turgid in the middle, suddenly truncated at both ends; the front auricled, no cerebral sacculi below the eye; toes thick. In bog-water, amongst Confervæ. 1-120″.

N. *decipiens.* — Cylindrical, not auricled; toes short; the ovarium often contains four large eggs. Perty thinks this is only the young of some other species. 1-180″.

N. (?) *Felis.*—Small, slender; one horn in front; eye colourless; back attenuated posteriorly, and forked. 1-240″.

N. (?) *Tigris* (*Trigoda Tigris,* M.) (xxxiii. 421).—Cylindrical, curved, foot half the length of the body; toes very long, and curved downwards; it has a little horn in front; the eye is large and red. Perty has found many examples without the red eye. Amongst Oscillatoriæ. 1-72″.

N. *longiseta* (*Vorticella longiseta,* M.).—Cylindrical, truncated anteriorly; toes styliform, unequal, and two to four times longer than the body. It is active, and frequently leaps, being assisted by its long claws, which resemble tails. Fig. 421 is a full-grown specimen. Entire length 1-60″.

N. *æqualis* (*Vorticella longiseta,* M.).—Cylindrical, obtuse in front; toes styliform, equal the length of the body. 1-120″.

b. *Subgenus* Ctenodon.—*Jaws many-toothed.*

N. *clavulata.*—Bell-shaped; foot conical, very short; pancreatic glands of a club-shape. This creature presents great facility for observing its internal structure; but the limits of this work preclude details. Mr. Gosse kindly informs us that he has distinctly seen in it a normal intestine terminating in the cloaca. 1-96″.

N. *Tuba.* — Conical, trumpet-shaped, dilated anteriorly; foot furcate and acute. It resembles, in form, *Stentor Mülleri,* but is more active. 1-120″.

N. *Brachionus.*—Dilated, nearly square, depressed, foot slender, eggs pendulous. This creature appears to have a shell, but Dr. E. says it has not. Ehrenberg described his *N. granularis* as depositing its eggs upon *N. Brachionus,* whence he concluded that the former, like the cuckoo, left its young to be reared by another creature. He found that some of the eggs on the dorsal surface of *N. Brachionus* produced *N. granularis.* Leydig solves the mystery by affirming that the latter species is the male of the former, the animal in this case being bisexual, not hermaphrodite. 1-96″.

N. *tripus.* — Oval, subtruncated, and slightly auricled in front. Dark red eye-speck with three chalky masses, giving the organ a trilobed appearance. Foot apparently trifid, but not really so, the central lobe being only the prolonged back of the animal. 1-200″.

N. *saccigera.*—Elongated, cylindrical, attenuated posteriorly; fork short. It has a curious internal pouch beneath the eye, with a group of rounded vesicles in front of the stomach, recalling, as Perty observes, the pretended agglomeration of eyes in *Theorus.*

N. *Copeus.*—Large, attenuated at both ends; tail small and indurated. This curious creature has a long bristle on each side of its body; and on each side of the head a stout process, called by Ehrenberg an auricle, fringed with vibratile cilia at its ends, and, like the setæ, standing out at right angles to the body; a thick gelatinous substance covers the body; the back terminates in a somewhat hard point, which is a true tail, between which and the foot the discharging opening is situated. When creeping, the large vibratile arms are withdrawn, but it vibrates with the frontal cilia and proboscis. (xxxiii. 416 represents the creature extended.) 1-36″.

N. *centrura* (xxxviii. 26).—Body large, attenuated at both ends. Usually surrounded by a broad gelatinous sheath, either hyaline or filled with small acicular bodies. According to Ehrenberg, in this sheath vegetate threads of *Hydrocrocis*; but these could not be found by Leydig. Sheath wanting in young specimens. Cuticle thick, soluble in caustic potass. Behind the middle of the body, on each side, is a small conical eminence (XXXVIII. 26 *b*), surmounted by a bunch of long setæ. Rotary organ peculiar, differing from Ehrenberg's representation. Anterior ciliated extremity small compared with the size of the animal; ventral portion (fig. 26 *d*) prolonged in the form of a half canal or groove, constituting a kind of under lip. At the base of this is the mouth, communicating with the maxillary bulb and œsophagus, and opening into a stomach with walls composed of large cells (fig. 26 *f*), beyond which is a restriction separating it from the rectum (fig. 26 *g*). Three sac-like organs (fig. 26 *t*, *c*) on the hinder border of the brain (fig. 26 *k*): the centre one composed of clear vesicles (fig. 26 *c*), the outer two apparently sometimes continuous with the cerebral ganglion. They are granular, nucleated, and apparent with some inorganic matter, which is white by reflected and dark by transmitted light. Ovary (fig. 26 *o*) transversal; Perty saw only winter ova in it. (XXXVII. 25 exhibits a small portion of the ovary in which an ovum is forming,—*a* being the germinal spot, *b* a clear space surrounding it, and *c* the yelk-substance. XXXVIII. 11. represents a small portion of the water-vascular canal with its tags, and fig. 12 the termination of a tag with its contained cilium.)

N. *brachyota*.—Small, slightly attenuated towards the ends; no tail, auricles very small; it has two dark spots near the eye; foot forked. 1-120″.

N. *Pleurotrocha*.—Slender, cylindrical, not auricled; foot with very short toes; eye obscure, ovate, large; jaw with one tooth. 1-144″. Berlin. Has the form of *Pleurotrocha*.

N. *vermicularis* (Duj.).—Vermiform, very contractile; of variable form, with a kidney-shaped red speck (XXXVIII. 33), in which is partly imbedded a white transparent globule. 1-118″. Found in the Seine.

N. *tardigrada* (Leydig) would be referable to the genus *Lindia* (Duj.), had not its author made the absence of cilia from the head a generic character. Figure vermiform, rounded in front, prolonged behind into a short biuncinate foot. Mouth a long fissure on the under side of the head, which is clothed with short and delicate cilia, the only part of the head so furnished. Maxillary bulb capable of being protruded. Dental apparatus recalling to mind that of *Echinus*. Œsophagus long, resembling that of *N. centrura*. Stomach long, yellow, without cilia on the free surfaces of its parietal cells. Intestine short and clear, opening at the base of the foot on the abdominal surface. Contractile sac visible, giving off traces of two water-canals, but without vibratile tags. Above the maxillary bulb the "sacculus cerebralis" of Ehrenberg, white by reflected and black by transmitted light, and soluble in *liquor potassæ*.

N. *roseola* (Perty).—Body of a pale rosy red, elongated, rounded in front. Rotary organ forming a cylindrical process on each side of the head. Cohn suggests that the animal may be identical with his *Lindia torulosa*.

N. *onisciformis* (Perty).—Body broad like an Oniscus, with a round lappet on each side of the head. Jaws strong, many-toothed; tail flat, rather long. Entire anterior extremity capable of being retracted. An ear-like lappet on each side of the head, between which are seen the vibratile cilia. No alimentary canal seen beyond the maxillary bulb. Amongst Confervæ and Charæ.

Genus SYNCHÆTA (XXXIII. 422).—Eye single, cervical; rotary organ of six to ten lobes, and armed with from two to four styles; foot furcate. The strong styles, or bristles, are situated between the clusters of cilia, and probably act as tactile organs; the body is very short, broad anteriorly, and tapers to a point posteriorly, or is conical. Internal longitudinal muscles exist in all the species; those of the foot are seen in three species: the œsophageal head is large, with single-toothed jaws; but in two species only is the whole chewing apparatus distinctly seen. The thin œsophagus is long in two species, short in the rest; it leads to a simple, wide, conical alimentary canal, which has two roundish, or, in one species, conical pancreatic glands.

The ovary is rolled up like a ball; contractile vesicles exist in three, and glands in two species; transverse bands (four to ten) are visible in two species, and probably a respiratory tube in *S. pectinata* and *S. tremula*, a tremulous gill being also present in the former. The principal nervous matter is a knotty mass surrounding the head of the œsophagus; and in the middle of it is a large, roundish, red eye. In *S. pectinata* three pair of ganglia and strong nerves are also said to be seen; but this is doubtful. Abdominal fluid of a reddish-yellow colour. (For remarks on the genus, see HYDATINA, p. 677.)

SYNCHÆTA *pectinata*.—Short, conical, with two styles and two crest-like horns anteriorly. "Are these horns," asks Ehrenberg, "respiratory tubes, as in *Polyarthra*, and in *Anuræa*?" The liveliness and uniform transparency of this animalcule render it difficult to distinguish its various organs. The styles arise from the muscle of the œsophageal head, and appear as if belonging to simple-toothed jaws. Eye blue. Egg-yelk containing heaps of red fat-globules. (XXXIII. 422, a dorsal view showing its organization.) Amongst Confervæ. 1-120″.

S. *Baltica*.—Ovate; rotary clusters and styles, four each; crest single, sessile. This creature is supposed to occasion phosphorescent light in the ocean. In two samples of water received by Ehrenberg at Berlin, from Kiel, the luminous property existed; but this species, though present, did not evolve any light. Michaelis, however, has noticed the production of light from this *Synchæta*, as did Baker a century ago. Ehrenberg thinks it takes place only when developing ova. 1-100″.

S. *oblonga*.—Oblong, with six rotary clusters, and four styles; crest sessile and single. Distinguished from the following by the form of the pancreatic glands. Amongst Confervæ in spring. Length about 1-100″.

S. *tremula* (*Vorticella tremula*, M.).—Body truly conical, with six rotary clusters, four styles; crest none; granules of yelk dark coloured. Length about 1-160″. Mr. Gosse thinks this may be a diœcious species.

S. *mordax* (Gosse).—Body conical, subventricose; toes minute; auricles large, pendent; principal styles four, the larger (or lateral) pair sometimes branched; eye rather small, brilliant; two pairs of protrusile snapping jaws. 1-72″.

Genus SCARIDIUM (XXXIII. 423).—Eye cervical, single, flat, lenticular, the compound rotary organ armed in front with an uncinus or hooked bristle; foot forked, very long, and adapted for leaping or springing—hence the name. Œsophageal head oblique, with unequal, double-pointed (single) teeth to the jaws; œsophagus short, narrow, opening into a simple, wide, conical alimentary canal; supposed glands spherical, two. Posteriorly, above the intestine, are a ball-like ovary and a contractile vesicle. The foot has two club-shaped muscles; and its apparent articulations are very remarkable. A central ganglion exists between the rotary lobes. Muscles with transverse striæ. Shell of the ovum (winter ovum?) clothed at both ends with scattered hairs.

SCARIDIUM *longicauda* (*Trichoda longicauda*, M.).—Foot twice as long as the body, toes half as long as the foot; the animal springs or leaps quickly, by a rapid movement of the foot; it does not appear to have a lorica, and is distinguished from all other Rotatoria by the length and bending-in of the foot, which, as also the body, is covered with a stiff skin. Behind the eye is a transverse fold in the neck, where the head draws itself into the body; the foot has also a transverse fold when it bends. (XXXIII. 423, the animalcule extended, right side; fig. 424 the œsophageal head, with unequal jaws, &c., extended by pressure.) Amongst Oscillatoriæ. Entire length of the body 1-72″; without the foot, 1-216″.

Genus POLYARTHRA (XXXIII. 400–402; XXXVIII. 30).—Eye single, cervical; foot absent; provided with cirri, or pectoral fins. The rotary organ consists of four bundles of cilia, inserted in as many muscular sheaths; they sometimes appear like the double rotary organ of a *Brachionus*. The form of the body resembles *Anuræa*; but it is soft, and the rotary organ double.

Laterally there are two longitudinal dorsal muscles; the frontal region has little horns, provided with bristles; and upon the breast are six strong styles, or barbs, forming two clusters, which move in a fin-like manner. The œsophageal head has two single-toothed jaws; œsophagus short; alimentary canal with a stomach-like division, produced by a constriction; supposed pancreatic glands, two. An ovary exists in both species, and in one of them a contractile vesicle; a large frontal ganglion and a round red eye indicate the system of sensation.

The preceding genera of this family, together with two peculiar to himself, viz. *Plagiognatha* and *Lindia*, form, in the system of Dujardin, the family Floscularíens; but the genus *Polyarthra* and a few others in this family of Ehrenberg belong to the *Brachioniens* of that author.

From the remarks of the French naturalist, it is to be inferred that he regards the distinction between *Polyarthra* and *Triarthra* as insufficient.

POLYARTHRA *platyptera* (XXXVIII. 30, also XXXIII. 400–402 & 425).—Ciliary wreath, according to Perty, *not* as described by Ehrenberg and Dujardin, but continuous and symmetrical, with two eminences crowded by setæ, besides which are several long styliform cilia. Near the posterior end of the body are two fossæ with unsymmetrically arranged setæ extending from them. Alimentary canal consisting of a conical œsophageal bulb, stomach, and intestine. Stomach-cells ciliated; contractile sac present, but no water-vascular system seen; longitudinal muscles striated; abdominal fluid yellowish-red; ovary somewhat bicornate; yelk of ovum with large reddish fat-globules. No winter ova seen. Embryo with bluish spots. Ova adhering to the exterior of the body; only one seen at a time (Leydig). It swims quickly, and often leaps, like the water-flea: this last motion is produced by the fins or pinnæ, the former by the vibratile organs. (Figs. 400, 401, & 425 represent the *P. Trigla* of authors; but Leydig has decided that it is identical with *P. platyptera*. Fig. 425 the under side while the animalcule is swimming, with the pinnæ depressed; fig. 400 a dorsal view while leaping or springing; and fig. 401 a side view, right.) This creature is infested with *Colacium*. Amongst Confervæ. 1-140''.

Genus DIGLENA (?).—Eyes two, frontal; foot forked. Excepting the foot and rotary organ, they have no external prominent organ, though some protrude the teeth in a pincer-like manner. The œsophageal bulb has single-toothed jaws; the œsophagus is very short, except in *D. lacustris*; alimentary canal conical, simple, in six, and constricted in two species. In all, two glands are present, which in *D. lacustris* are long cylindrical and two-horned; in the rest they are spherical. The ovary in *D. lacustris* is band-like, in the others globose. Contractile vesicles are observed in four species. No species is viviparous; none carry their egg hanging to them; transverse muscular bands are seen in three, and in one a vascular network at the head; tremulous tags are found in three species, in two of which they appear as if attached to the water-vascular-canal glands. The cerebral ganglion is more especially developed in *D. lacustris*, but is indicated in all the species by the coloured eyes.

DIGLENA *lacustris*.—Stout, oval, crystalline; the front straightly truncated; foot suddenly attenuated, in length one-fourth of the body; the toes one-third the length of the foot. The transparency of this animalcule is often a great hindrance to the discrimination of its internal organs, though they are very large; the superficial skin is delicately shagreened. (XXXIII. 403 a side view, left, of this interesting animalcule, with a Lynceus—see *Microscopic Cabinet*, pl. vii.—in its stomach; its curious internal organization is clearly depicted. Often found in green-coloured water.) 1-70''.

D. *grandis*.—Long, slender, and cylindrical, obliquely truncated anteriorly; toes straight, longer than the stout foot. The forked central sacculus, near the head, is remarkable. (XXXIII. 404 an extended animalcule, right side; XXXIII. 405 another, contracted, with the jaws pushed out.) 1-120″ to 1-72″.

D. *forcipata* (*Vorticella vermicularis, Cercaria forcipata* et *E. vermicularis*, M.) (XL. 24).—Cylindrical, slender, obliquely truncated anteriorly; toes decurved, and longer than the stout foot. 1-110″.

D. (?) *aurita* (*Vorticella Canicula*, M.). —Cylindrical, slender; front straightly truncated, auricled; foot suddenly constricted, toes small. The tremulous organ observed by Corti was merely the vibratile lining membrane of the anterior portion of the alimentary canal. Amongst Confervæ. 1-160″.

D. *catellina* (*Cercaria catellina, Vorticella Larva*, M.).—Oblong, short, ends truncated; foot short, and inferior. The small size of this animalcule is unfavourable for observing its internal organization. It is found at all seasons of the year in open water, and in infusions covered with a green pellicle, which is often filled with its eggs; these, when rapidly developed by genial weather, cause a milky turbidity in the water. 1-360″.

D. *conura*.—Ovate-oblong, straightly truncated in front, and gradually attenuated to a conical foot. Amongst Oscillatoriæ. 1-144″.

D. *capitata*.—Oblong, conical, obliquely truncated and dilated in front; toes long, without apparent base, or foot. Feeds upon *Chlamydomonas* and *Navicula*. 1-300″.

D. *caudata* (*Vorticella furcata*, M.).—Elongated, conical, obliquely truncated anteriorly, but not dilated; foot distinct, short; toes long. In green water. 1-200″.

D. (?) *biraphis* (Gosse).—Oblong, the head and abdomen gently swelling; toes long, slender, straight, and perfectly even in thickness; eyes placed close together, frontally; jaws protrusile; alimentary canal very large, projecting behind and above the gizzard, always filled with green matter. Length, including toes, 1-110″.

Genus TRIARTHRA (XXXIII. 406–408).—Eyes two, frontal; foot simple, styliform; breast-fins two. Beside the rotary organ, internal bandlike muscles are observed, and two bristles, or fins, which assist in leaping, as in *Polyarthra*. The œsophageal bulb has two double-toothed jaws, as in *Rotifer*; the œsophagus is long in one species, short in the other; alimentary canal simple, conical or constricted, with two spherical glands. An ovary and contractile vesicles are seen; the eggs, when expelled, remain attached by threads. The nervous system is indicated by the two red eyes, placed upon ganglia. Both species often produce a milky, turbid appearance in the water, when developed in masses. A third species is now added.

T. *longiseta* (*Trichoda*, M.).—Eyes distant; the cirri or beards, and the foot, are nearly three times the length of the body. This species is distinguished from the following one by the greater length of cirri; by larger eyes, further removed from each other; by a distinct stomach, with a constriction separating it from the long portion of the alimentary canal; and, lastly, by its long œsophageal tube. It is readily distinguished by its leaping movement whilst swimming. (XXXIII. 408, a young animal emerging from the egg, the cirri or styles being, as yet, soft; 407, back view of a young specimen—it shows the great separation of the eyes and the styles, in the position they occupy when the animal is swimming; 406 a side (right) view of a full-grown specimen—the styles are advanced, preparatory to leaping.) Found with *Hydatina senta* and *Brachionus urceolaris*. Length, without cirrhi, 1-140″.

T. *mystacina* (*Brachionus passus*, M.).—Eyes close together; two anterior cirri, or bristles; foot nearly double the length of the body; jaws very soft. 1-216″. In water-tubs.

T. *breviseta* (Gosse). — Cylindrical; pectoral and caudal spines each about one-fifth of total length, and very slender. Length, including foot, 1-185″. Leamington.

Genus RATTULUS (XXXIII. 409).—Eyes two, frontal; foot simple, styliform; no cirri or beard. The organization at present discovered comprehends several undefined rotary muscles, an œsophageal head, without distinct teeth or œsophageal tube, a simple conical alimentary canal, with two round glands, an ovary, and the eyes.

This genus (*Rattulus*, or *Ratulus*) was established by Lamarck; but the animals included in it by him were referred by Ehrenberg to two genera, *Mastigocerca* and *Monocerca*, and the term *Rattulus* conferred upon an animal placed among Cercariæ, and called by Müller *Trichoda lunaris*. "The *Mastigocerca carinata* (Ehr.)," observes Dujardin, "is described as loricated, and enters into the family Euchlanidota; and *Monocerca Rattus*, without lorica, is placed among the Hydatinæa; but the beings described under these two appellations represent but a single species, *Ratulus* . . . . The *Monocerca bicornis* of Ehrenberg would seem to be a distinct species, by reason of the horns with which it is armed in front."

RATTULUS *lunaris* (*Trichoda lunaris*, M.). — Small; eyes remote from the frontal margin; foot decurved, lunate. No teeth are seen (XXXIII. group 409). In turfy pools. 1-288".

R. *carinatus* (Duj.) (XXXVIII. 22) = *Monocerca Rattus*.

Genus DISTEMMA.—Eyes two, cervical; foot forked; rotary organ compound. The œsophageal head supports, in three species, jaws, with two teeth each; in one species with more than two; œsophagus short; alimentary canal simple, conical, with two spherical glands. An ovary, and in *D.* (?) *marinum* glands and a contractile vesicle are seen. No satisfactory details of a water-vascular system are ascertained; the eyes are red, except in one species, in which they are colourless, and in all, except *D. marinum*, they are situated behind the head of the œsophagus; in that one they are anterior, but below the rotary organ. The eggs are never attached to the parent, nor are they developed in large masses.

DISTEMMA *Forficula*. — Cylindrico-conical; eyes red; toes thick, recurved and dentate at the base. The eyes are placed at the end of a long cylindrical nervous ganglion; the rotary organ consists of four parts. XXXIII. 411 is a side (left) view, and fig. 410 shows the jaws extended for seizing prey. Perty believes this to be identical with *Furcularia Forficula*, having but a single eye. 1-120".

D. *setigerum*. — Ovato-oblong; eyes red; toes setaceous and decurved. 1-216".

D. (?) *marinum*.—Ovato-conical; eyes red, close together; foot long; toes thick, the length of the foot; jaws many-toothed. In sea-water. 1-144".

D. (?) *forcipatum*. — Ovato-oblong; eyes colourless; foot short, with stout toes. If the two colourless vesicles are not eyes, it must be placed in the genus *Pleurotrocha*. 1-288".

Genus TRIOPHTHALMUS (XXXIII. 412–414).—Eyes three, cervical, sessile, in a row; foot forked; rotary organ compound. It has a large œsophageal head, with two (single-toothed?) jaws, a long thin œsophagus, a globose stomach-like protuberance, with two oval glands, and a thin intestine; two muscles move the foot. Several small tags seen in *T. dorsalis*.

TRIOPHTHALMUS *dorsalis*.—Body crystalline, turgid; central eye largest; foot suddenly attenuated, its length half that of the body. This species, in form, resembles *Notommata ansata*, but in size *N. Myrmeleo*. (XXXIII. 412, dorsal side of an animalcule extended as it appears when swimming and vibrating; fig. 413 one in the act of unfolding itself, and fig. 414 another contracted.) 1-40".

Genus EOSPHORA (XXXIII. 415). — Eyes, according to Ehrenberg, sessile, three—two frontal, one cervical; foot forked. The rotary organ is composed of numerous muscular portions. An œsophageal head, provided with two single-toothed jaws, a short œsophagus, a simple conical alimentary canal, with two ovate glands anteriorly, an ovary, somewhat extended, and a contractile vesicle, are also discoverable. Transverse bands are observable in two species, and tags in the third. Beside the three red-coloured eyes, a cerebral ganglion is seen. Distinctly striated longitudinal muscles are seen in all.

According to Leydig, what Ehrenberg has regarded as two frontal eyes have no claim to the name. Should this statement be confirmed, it would become necessary to unite *Eosphora* with *Notommata*.

EOSPHORA *Najas*.—Conical, transparent, not auricled; toes much shorter than the foot. (XXXIII. 415, an animalcule fed upon indigo.) Amongst Conferva. 1-12″.

E. *digitata*.—Conical, hyaline, not auricled; toes a third the length of the foot. Amongst Conferva. 1-96″.

E. *elongata*.—Elongated, almost fusiform, not auricled, front truncated; toes short. 1-72″.

Genus OTOGLENA.—Eyes three, one being sessile and cervical, the others pedicled and frontal; foot furcated. This large animalcule, the sole representative of this genus, has considerable resemblance to *Notommata Myrmeleo* or *N. clavulata*. Four lateral longitudinal muscles, six moving the rotary organ, and two muscles of the foot are present; a toothless, and apparently jawless, œsophageal canal leads to a somewhat thickened stomach, ending in a very thin intestinal canal. An ovary and contractile vesicles are observed. A vascular network at the neck represents a water-vascular system. An oval cerebral ganglion, with two dark appendages, and a red eye, together with two little horn-like or auricular frontal protuberances bearing two visual points, represent the nervous system. This genus has not been figured.

OTOGLENA *papillosa*. — Bell-shaped, turgid, scabrous with papillæ. Found with *Volvox Globator* and *Notommata Myrmeleo*. 1-96″.

Genus CYCLOGENA (XXXIV. 425, 426).—Eyes numerous (more than three), conglomerate at the neck; foot furcate. The vibratile organ is compound, and, with the internal muscles of the foot, serves for locomotion. The œsophageal head has two single-toothed (perhaps three-toothed) jaws; œsophagus very short; alimentary canal conical, simple, with two roundish glands. An ovary and a contractile vesicle are also present. Transverse circular muscles, and six pair of tremulous organs attached to the water-vascular canals, exist. A purse-shaped dark (colourless) body in the neck, connected by a narrow process to a large frontal ganglion, containing from six to twelve red points, of which the anterior one is most marked, possibly indicates a system of sensation.

CYCLOGENA *Lupus* (*Cercaria Lupus*, M.). — Ovato-oblong, or conical, not auricled; foot terminal, and short. (XXXIV. 425 * a back view, 426 a side view.) 1-120″.

C. (?) *elegans*.—Ovate, not auricled; foot inferior; toes long. 1-190″.

Genus THEORUS (XXXIV. 427–429). — Eyes numerous (more than three), disposed in two groups at the neck; foot furcate. A compound rotary organ, together with two muscles of the foot, an œsophageal head, with two one-toothed jaws, a short œsophagus, a simple conical alimentary canal, with two glands, a ball-like ovarium, and a double group of colourless cervical eyes, are the details of the organization at present known. The frontal uncinus, or hook, is perhaps a respiratory tube. Perty doubts if Ehrenberg is correct in his interpretation of the supposed agglomeration of the eyes in *Theorus*.

THEORUS *vernalis*. — Toes small; no frontal uncinus. The movement of this creature is active and vehement, like that of an animal of prey. (XXXIV. 427, a back view of this animalcule extended, with six colourless eyes in each group; 428, a specimen with four eyes; 429, body contracted, but jaws extended.) Amongst Oscillatoriæ. 1-140″.

T. *uncinatus.* — Toes long, a frontal uncinus, or hook, present. Six visual points have been seen by Ehrenberg. Amongst Oscillatoriæ. 1-240″

The two next genera mentioned are from Mr. Gosse, who, however, adduces the latter one as a doubtful member of the present family.

Genus ASPLANCHNA (Gosse, *A. N. H.* 1850, vol. vi.) (XII. 65, 66; XXXVI. 7–9; XXXVII. 27–32).—Rotatorial Hydatinæa destitute of foot, intestine and anus, but possessing eyes (ocelli) and jaws; sexes disjoined.

This new genus embraces the Rotatorial animal which Mr. Brightwell introduced to notice as "a supposed new species of *Notommata*" (*Fauna Infusoria, Norfolk,* 1849), and in which he first detected the existence of male animals distinct in organization and character from the female. It was soon perceived that the new forms represented by Mr. Brightwell could not belong to the genus *Notommata* of Ehrenberg; and the discovery of other similar beings has led to the creation of this genus *Asplanchna.*

Asplanchna *Brightwellii.* — Jaws (mandibles) one-toothed; eye single; stomach oval, longitudinal; vesicle lobed, larger; tremulous corpuscles (gills, Ehr.) affixed to a long filament; ovary two-horned. Length about 1-24″. (xii. 65, 66.) Males with jaws, pharynx, and stomach absent; body truncate. Length about 1-40″. Found at Norwich, Leamington, Hampstead Heath, &c.

Mr. Brightwell's account is embraced in the following extracts:—

"It (the female) is furnished with an ovisac, in which the young may be clearly detected, and from which they are expelled through the sides of the animal. Some of the young appear to differ in form from the others, and there appear to be two kinds of ova,—one, and that by far the greater number, transparent, and hatched in the body of the parent; the other, more opaque, perhaps remaining unhatched, or deposited till vivified under favourable circumstances in some ensuing season. Should this, on further investigation, turn out to be the case, we shall have, among the Rotifera, the same mode of preserving the ova during the winter as is found in some of the Entomostraca, the *Daphniæ* for instance."

"These [the males] are smaller than the females, and have a pyriform sac below, from which there is an opening, and which is filled with spermatozoa; and they have neither jaws, nor gullet, nor stomach; and it would seem they are designed, as is the case with the males of some insects, to continue the race and then to perish.... I have lately repeatedly seen the male in connexion with the female. He attaches himself to her side by his sperm-tube, and remains attached from twenty to seventy seconds."

For a more complete description of these very interesting forms we may refer the reader to the elaborate details and figures of their organization, by Mr. Dalrymple, in the *Philosophical Transactions* for 1849, and to Part I. p. 453 *et seq.* of this volume.

Notommata Anglica of Leydig appears to be only Mr. Gosse's *Asplanchna Brightwellii.*

A. *priodonta* (Gosse).—Females: Jaws serrated; eyes three; stomach hemispherical, transverse; vesicle spherical, smaller; tremulous bodies attached to a twisted and plicate filament; ovary subglobose (xxxvi. 9; xxxviii. 28). Length about 1-48″. Males: Body acute (xxxvi. 7, 8). 1-110″. Found in the Serpentine river. (Figs. 10, 11 exhibit the jaws of the female detached.)

A. *Sieboldii* (*Notommata Sieboldii,* Leydig) (xxxvii. 27–32).—Females closely resemble those of Leydig's *N. Anglica,* but the males differ widely. Female campanulate, no foot; anterior extremity widened; ciliary wreath interrupted by a fissure at the mouth, into which the fine cilia descend; two large lobes (32 *g*) on the rotary organ, crowded by setæ, with two similar smaller ones; between these, on each side, is a fossa with long motionless setæ. Mouth opening into an angular maxillary bulb. Jaws (xxxvii. 31) with one furcate piece hooked at the end; on the inside is an aculeate process and a ridge to which strong striated muscles, working the jaws, are attached. Œsophagus long, its lower end highly muscular; two spherical glands open into the round yellowish-brown stomach (32 *b*); intestine absent. Walls of the contractile vesicle (32 *e*), which open into the cloaca, with a muscular network. Two water-vascular canals on each side, one with granular walls, the other wider and with about fifty tags (31 & 32). Cerebral ganglion laid across the maxillary bulb, with a dark-red or black speck above and behind it in the median line. Cells of the ganglion, according to Leydig, fusiform, and prolonged into nervous cords. A nerve is said to proceed from each side to the setigerous fossa of the rotary organ, where it swells out like a ganglion; another nerve, from its posterior surface, divides to supply the smaller eminences on the rotary organ; and another pair from the same surface supply the smaller eminences: but we think these supposed nerves require re-examination. Ovary horseshoe-shaped (32 *c*). Male and female young never simultaneously generated within the same parent. Winter eggs (XXXVII. 27, 28) spherical, usually one or two, never more than three; yelk yellowish-red, invested by a thin membrane, which in turn is surrounded by a thick granular tuberculated shell, the latter rendered pale by potash, which partly obliterates the tubercles. On keeping specimens in pure water without nourishment, all the eggs deposited were winter ova. Males differ in figure (fig. 29) from females: clavate, with four conical arms; the two anterior ones (29 *a*) the smallest. When swimming, which it does on its back, these arms are shortened. Rotary, muscular, and nervous structures as in the females. Pyriform testicle (29 *e*) next the contractile sac, filled with spermatozoa, amongst which are round vesicles, nucleated fusiform bodies (30 *b*, *c*), curved, nucleated, sickle-shaped objects (30 *a*), and stiff, sharply-defined rod-like bodies (30 *f*). Duct on the abdominal surface at the end of the body, and surrounded by what look like accessory glands. Alimentary canal absent; the rudimentary digestive organs represented by an irregular heap of cells behind the posterior anus. Young males born alive.

Genus TAPHROCAMPA (Gosse).—Rotary organ wanting, body fusiform, annulose; tail forked; gizzard oval; mallei incurved, shorter than the incus, which is also incurved.

TAPHROCAMPA *annulosa*. — Occipital mass opaque, white; alimentary canal simple, wide, cylindrical; points of tail short, conical. 1-110″.

This species is evidently allied to M. Dujardin's *Lindia torulosa*, but differs from it in the structure of the dental apparatus, and of the digestive canal. It seems to connect the genus *Chætonotus* with the Hydatinæan genera *Notommata* and *Furcularia*; for it has the jaws of these larviform Rotifera, and the glandular occipital mass found in some of them, with the form, simple digestive canal, and manners of *Chætonotus*. Found at Leamington.

We will append here two genera of the family Furculariens of Dujardin, which that naturalist has created either to embrace new species or to dispose of those described by Ehrenberg which Dujardin cannot include with other of his genera. Likewise, before commencing with the next family (Euchlanidota of Ehrenberg), we shall take the opportunity to detail the characters of a family discovered and named by Dujardin, viz. Albertiens.

Genus PLAGIOGNATHA (Duj.).—Body oblong, curved and convex on one side, or cornet-shaped and obliquely truncate in front; terminated posteriorly by a more or less distinct tail, bearing two styles. Jaws with parallel branches turned the same way, and recurved towards the ciliated margin with a straight central stem (fulcrum), very long and enlarged at its base; eyespecks one or two. We propose this as a genus of Furculariens.

Although possessing a curved figure, with a characteristic form of jaws, Ehrenberg has distributed them in his genera *Notommata*, *Diglena*, and

Distemma, according to the number and disposition of their red points, and without consideration of the characters we employ.

PLAGIOGNATHA *Felis.* — The species we regard as the type of this genus is the *P. Felis*, called by Müller *Vorticella Felis*, but not answerable to the *Notammata Felis* of Ehrenberg. Its two styles are one-fourth of its entire length, and are curved backwards; the back is convex, abruptly truncate behind. 1-118″.

PL. *lacinulata* has been classed by Ehrenberg among the *Notommatæ*. A variety of this species with two eye-specks may be referred to the *Distemma setigera* (Ehr.).

One must also regard as distinct species of *Plagiognatha* the *Notommata Tigris* and the *Diglena catellina* of Ehrenberg. The *Diglena lacustris* of the same author also corresponds in form; but its jaws are not sufficiently described to determine its position; whilst his *Notommata hyptopus*, represented with one-toothed jaws, analogous to those of our *Furcularia*, appears the same as a *Systolide* known to us, evidently possessing the jaws of a *Plagiognatha*.

Genus LINDIA (Duj.) (XXXIX. 1–3).—Body oblong, almost vermicular, articulated by means of shallow transverse folds, rounded in front; protrudes, when swimming, two small clavate organs (3 *n*), clothed with radiating cilia at their extremities, and forming a retractile rotary organ on each side. Jaws (fig. 2) composed of three pincer-like teeth. Eye-speck single, in front of a blackish calcareous (?) sac. Two short conical toes at the posterior extremity.

LINDIA *torulosa* (Duj.). — Body reddish. Length 1-6‴, Perty; 1-7‴, Dujardin; 1-8‴, Cohn. Cohn, whose amended characters of the genus we have given above, thinks that *Notommata roseola* may be identical with this species: the latter differs from *Notommata tardigrada*, which it much resembles, in the presence of the club-like rotary organ. Our author also contends, in opposition to Dujardin, that the œsophagus is ciliated. It is not, however, quite certain that they refer to the same animal. It is distinct from *Notommata vermicularis*, which it resembles. Cohn thinks the genus *Lindia* should be located amongst Philodinæa.

FAMILY OF THE ALBERTINA (ALBERTIENS).

Body cylindrical, vermiform, round in front, with an oblique opening, from which a ciliated organ protrudes itself, almost larger than the body; terminated posteriorly by a short conical tail. Jaws in the form of hooks, simple, or with one tooth each.

This family comprises but one genus, and one species, *Albertia vermicularis* (XXXVIII. 35, 36), which is found parasitic in the intestine of *Lumbrici* and snails. 1-79″ to 1-47″.

The ova with their embryos are seen in its interior, in various stages of development.

The ciliated apparatus, in advance of the mouth, is surrounded by an appendage in the shape of a spur (calcar).

FAMILY VI.—EUCHLANIDOTA.

This family comprehends such Rotatoria as have a compound rotary organ with more than two subdivisions, and whose bodies are enclosed in a hardened lorica. The latter is very variable in form. Ehrenberg has remarked that it sometimes resembles the hard carapaces of tortoises, at others the shells of crabs. In the former case the lorica is open at the extremities; and in the latter, Ehrenberg supposed it to be open inferiorly in *Euchlanis*; but this is denied by Cohn, whose testimony is to be relied upon. The animal contained within this lorica presents the typical features of the Rotatorian class, just as some minute Crustaceans (Entomostraca), though enclosed between bivalved cases, retain the internal organization of their more conspicuous and shelless allies. The Euchlanidota are provided with the various Rotatorian appendages—these exist as setæ, uncini, spurs, or tactile organs; and all are provided with the characteristic tail or foot terminating in one or two digits, this organ being largely employed in locomotion, either as a rudder or as an anchor. The hardened tegument forming the lorica is variously prolonged into spines and other appendages. Sometimes these are most developed anteriorly, at others posteriorly, whilst in *Stephanops* a broad expansion of the front of the lorica is developed into a curious crystalline hood. The surfaces of the lorica likewise are variously sculptured and ornamented.

The eye-speck, to which Ehrenberg has attached such importance in his subdivision of this family, possesses, as Dujardin has pointed out, less value as a basis of classification than the Prussian observer supposed; but if the observations of Leydig prove correct, the organ acquires additional interest from the discovery of a refracting body in the eyes of *Euchlanis unisetata* and *Stephanops lamellaris*. Should these observations be confirmed, they will do much to remove all doubt respecting the visual character of these organs,—doubts which are naturally suggested by the improbability of visual organs being given to the embryo encased in the egg, whilst the matured, active, bustling animalcule becomes deprived of them when its life seems to render their presence most necessary. The exact nature of the internal organization of most of the Euchlanidota is yet uncertain, and requires further study; but each form, when minutely examined, is found to approximate more closely to the Rotatorian type. Thus, whilst all are provided with a muscular system, Cohn has demonstrated that in *Euchlanis* the fibres are of the striped or voluntary type. The same observer has also shown that *Euchlanis dilatata* is bisexual, the males resembling those of *Hydatina* and *Asplanchna* in being unsupplied with an alimentary canal. These are approximations towards a general reduction of the whole class to a common type of organization of a higher character than was formerly thought to exist amongst Rotifera, but at the same time very different to what was originally attributed to them by Ehrenberg. The genus *Lepadella* developes itself occasionally in such myriads, in stagnant water, as to give a whitish turbidity to it.

Ehrenberg's arrangement of the genera is given at p. 478. Dujardin includes most of the genera in his family Brachioniens.

Genus LEPADELLA (XXXIV. 430–433).—Eyes absent; foot furcate. Several trochal muscles are seen, and foot ones in two species. The jaws of the œsophageal head are single-toothed in *L. ovalis* and *L. emarginata*; in *L. Salpina* triple-toothed. The œsophagus is very short in all; the alimentary canal below is constricted, except in *L. Salpina*, in which it is simple. The ovary is globular in all; in *L. Salpina* probably a cerebral ganglion (no eye) exists. *L. ovalis* is sometimes developed in myriads in stagnant water.

Dujardin has the following criticisms on the genus *Lepadella*:—"Wishing to derive his generic characters too exclusively from the eye-specks, Ehrenberg has separated all those having such specks into several genera; constituting of those with two eye-points the genera *Stephanops* and *Metopidia*, and of those with four red specks the genus *Squamella*. But we are convinced that these red points may be present or absent in the same species at different periods of development. We believe, for instance, that the *Lepadella ovalis* and *Stephanops muticus* (Ehr.) are but a single species; *Lepadella*

Patella with or without red dots; so also the *Metopidia Lepadella* and *Squamella bractea* are the same, and what we name *Lepadella rotundata.* Moreover the *Squamella oblonga* and *Metopidia acuminata* are two distinct species of *Lepadella.*"

Lepadella *ovalis* (*Brachionus ovalis*, M.).—Lorica depressed, oval, not emarginate, attenuated anteriorly, the ends truncated. The alimentary canal of this animalcule is generally filled with a yellowish substance, except when it feeds upon colourless Monads. (xxxiv. 430, a back view; 431, a side (right) view of a young specimen; 432, the lorica; 433, the œsophageal head.) 1-240″.

L. *emarginata* (*Brachionus Spatella* et *ovalis*, M.). — Lorica depressed, oval, broad anteriorly, extremities emarginate. Amongst Confervæ. Length, without foot, 1-576″.

L. (?) *Salpina*. — Lorica oblong, prismatic, obtusely triangular, back crested, denticulated. Amongst Confervæ. Length of lorica 1-200″.

Genus DIPLAX (Gosse).—Resembles *Salpina*; but the eye is wanting, and the lorica (which, as in that genus, is cleft down the back) is destitute of spines both in front and rear; foot and toes long and slender. It forms a connecting link between *Salpina* and *Dinocharis*. The name, signifying double, alludes to the gaping lorica, which forms two parallel plates.

In accordance with the tabular disposition of the family, this genus follows next after *Lepadella*.

Diplax *compressa*. — Form of lorica (viewed laterally) nearly a parallelogram, greatly compressed. Lorica 1-176″.

D. *trigona*.—Lorica three-sided, a section forming a nearly equilateral triangle, surface delicately punctured or stippled; toes long and slender. Lorica 1-160″. Leamington.

Genus MONOSTYLA (XXXIV. 434–437). — Eye single, cervical; foot simple, styliform; lorica (*testula*) depressed, ovate. Numerous muscles have been noted in two species—the œsophageal head has four muscles; in one species the jaws are single-toothed, in the other two-toothed. Œsophagus very short; stomach constricted (Gasterodela), with two glands. The ovary is globular; an ovum, with the vesicle of the germ within it, was seen in two species. No male organs, vessels, or respiratory tubes, are seen. Owing to the almost constant vibration of the foot-like tail, it is difficult to observe the true form of its termination, the motion producing an optical deception; hence it appears double, though in reality it is single.

Monostyla *cornuta* (*Trichoda cornuta*, M.). — Lorica hyaline, unarmed, and truncated anteriorly. Amongst Charæ and Confervæ. 1-250″.

M. *quadridentata*. — Lorica yellowish, anteriorly deeply dentated, resembling four horns. It is generally of a yellow leather colour, but Ehrenberg has seen it colourless. (xxxiv. 434 & 435, ventral aspect; in the latter the animal is extended beyond its lorica, which happens when the rotary cilia are in motion. Fig. 436, a side view; 437, the jaws and teeth separated.) In floccose matter about Confervæ and the leaves of water-plants. 1-120″.

M. (?) *lunaris*.—Lorica hyaline, flexible, admitting the retraction of the head, anteriorly crescent-shaped. 1-144″. Colour grey, usually so dark that no internal organs are distinguishable. Eyes red; jaws large, two-toothed; eggs few.

M. *Bulla* (Gosse). — Body ovate, inflated, the back very gibbous; lorica plicated on each side, with a deep furrow; the occipital and mental deeply incised. Colour yellowish-brown. Length of lorica 1-175″.

Genus MASTIGOCERCA (XXXIV. 438–440).—Dujardin and Perty believe this to be identical with *Monocerca*.

Genus EUCHLANIS (XXXIV. 441–446; XXXVIII. 5, 18; XXXIX. 4, 5, 7).—Lorica resembling a tortoise-shell; according to Cohn not slit inferiorly, as described by Ehrenberg. Dorsal and ventral plates united along the sides, forming an acute ridge, leaving a fissure, posteriorly, for the foot. Dorsal plate the largest. Frontal portion of the animal retractile within the lorica; deeply cleft on its ventral aspect, with the oral orifice at the bottom of the cleft. Expanded anteriorly into lappets supporting hooked bristles. On either side is a conical process terminated by a long stiff seta. Œsophagus capacious; jaws resembling those of *Hydatina* and *Brachionus*. Stomach thick and rounded, with two small spherical glands. Intestine pyriform, ending in a cloaca at the posterior border of the ventral plate; both ciliated. Contractile vesicle opening into the cloaca, sending up on each side a coiled water-vessel with about four vibratile tags. Longitudinal muscles strong, striated. A large trapezoid cellulo-granular organ in the head, with a red speck near its front extremity, and on each side a long, finely granular saccular appendage. Tail with three telescope segments, ending in two long knife-like toes.

Dujardin does not admit the genus *Monostyla*, but places its three species in the present one—*Euchlanis*.

EUCHLANIS (?) *triquetra* (XXXVIII. 5 *a*).—Lorica very large, trilateral, with a dorsal crest; setæ on foot, none. This species is very diaphanous; and "therefore," remarks Ehrenberg, "I was never able to see the line of division on the ventral surface of the lorica. The relationship of the fibres of the lateral muscles is physiologically and anatomically interesting: they form three bundles, on each side, and show as distinct corrugations as do the muscles of larger animals." (XXXIV. 443, a fore-shortened view; 442, a left side view, showing the dorsal crest of the lorica: at the base of the foot an external empty fold of the skin is visible. Fig. 441, the ventral surface, showing an opening for the foot, but no division of the lorica; 444, the teeth and jaws separated.) In turf-pools. Length 1-48″; ovum 1-192″. (XXXVIII. 5.)

E. (?) *Hornemanni*. — Lorica thin, short, cup-shaped, truncate in front, the anterior part of the body soft (pliant) and elongated. This creature appears able to draw within the lorica both foot and head. Sometimes longitudinal muscles are apparent. 1-432″ to 1-240″.

E. *Luna* (*Cercaria Luna*, M.).—Lorica cup-shaped, the front excised in a lunate manner, toes with claws. The single-toothed jaw, the constriction of the alimentary canal, and the claws distinguish it from the other species. Amongst *Ceratophyllum* and Confervæ. 1-144″. According to Perty, specimens occur of a rosy red colour.

E. *macrura*.—Lorica large, ovate, depressed; bristles at the base of the foot; toes long, styliform. This species is distinguished from the following one by its stronger and longer toes. "Lately," says Ehrenberg, "I saw the division of the lorica along the ventral surface." Each jaw has five teeth; and there are two soft maxillary appendages, each with two teeth. Amongst Confervæ in clear water. Length, without foot, 1-96″. Perty states that the stomach and intestines are sometimes red.

E. *dilatata* (*Brachionus*, M.).—Lorica broad, depressed, folded on the under side; foot without setæ; toes long. This animalcule, when it emerges from the egg, has a very soft lorica, and resembles *Notommata*. Cohn states that the males of *E. dilatata* are like the female, only smaller and more slender, as well as more transparent from the absence of mouth, œsophageal bulb, and intestine. The testis of the male occupies the centre of the body, and is a lancet-like elongated sac (XXXIX. 5 *h*), extending from the cloaca to the cerebral ganglion, and filled with rod-like spermatozoa. At its posterior extremity it is in connexion with a reniform body surrounding and opening into the penis. The latter has a thick wall and a ciliated canal protruding as far as the first segment of the tail (5 *p e*). Length of lorica 1-8‴ to 1-20‴ (figs. 4, 5, 7).

E. *Lynceus*. — Lorica ovate, turgid, deeply fluted; two little horns project anteriorly. (XXXIV. 445, a back view; and 446, a side view); the lorica is open along the middle of the under side. Length of lorica 1-216″.

E. *deflexa* (Gosse).—Body semioval; ventral surface of the lorica divided longitudinally, and the edges of the fissure bent out at right angles; foot furnished with two pairs of bristles; toes spindle-shaped. Lorica 1-80″.

E. *pyriformis*.—Outline (viewed dorsally) nearly oval, with a slight constriction in the middle; lorica divided longitudinally along the ventral surface, the gape widening anteriorly; toes parallel, edged; eye minute. Lorica 1-62″.

E. *Hipposideros.*—Nearly oval in outline; the ventral side flat; the dorsal greatly arched, and ridged down the middle; lorica formed of two distinct plates; the dorsal plate enveloping the back and half down the sides; the ventral separated from it by a wide space, and hollowed in the middle, so as to present the figure of a narrow horseshoe, whose points are forwards; foot armed with one pair of bristles. Lorica 1-110″.

E. *emarginata* (Eichwald).—Distinguished from *E. Luna* by a projection at the end of each tail-flap.

E. *bicarinata* (Perty).—Body elongated. Dorsum of lorica with two parallel keels, rounded behind. Tail long, with two terminal pincers; body wide in the middle, contracted towards each end. Middle joint of the tail very long; toe-segment very short. Eye blackish-red. It is allied to *E. Weissii* of Eichwald, but distinguished by its long figure and long setæ of tail. 1-6‴. Perty believes that this species connects *Euchlanis* with *Salpina*. Leydig regards it as a *Salpina*.

E. *unisetata* (Leydig.)—Size of *E. dilatata*. It has a single long bristle located on the dorsal surface of the foot-articulation; and, according to Leydig, the eye has a refracting lens (XXXVIII. 18).

Genus SALPINA (XXXIV. 447–453).—Eye single, cervical; foot furcate; lorica prismatic, with bulging sides, closed below, and terminated by spine-like processes or teeth. "The lorica," says Ehrenberg, "resembles a three-sided little casket, with arched sides, flat below, and having, anteriorly and posteriorly, at the truncated extremities, little points." The animalcule can entirely withdraw itself within the lorica. All the species have an elevated ridge upon the back, which in some appears to be double. A compound rotary organ, two short anterior lateral, and two foot muscles are seen in *S. mucronata*. An œsophageal head, with three- or four-toothed jaws, a short œsophagus, and a simple conical alimentary canal exist in all the species; in five the conical intestine has two spherical glands. The ovary is distinct. A spur or tube is observed at the neck in three species; the red eye in connexion with a cerebral ganglion is always present. They do not increase in large masses.

SALPINA *mucronata* (*Brachionus mucronatus*, M.).—Lorica very minutely scabrous, anteriorly with four, and posteriorly with three horns, generally straight and of equal length. The lorica, when the creature is young, is soft and bent, but soon hardens, and produces horns. The spur, or tactile tube, in the neck, terminates in a little bristle, as seen in XXXIV. 450. In some specimens, Ehrenberg says, the lorica appears as if punctate or stippled. (447, 448, full-grown specimens, with the head withdrawn; the latter figure is a back view, the former an under one; 449, a side view, head extended; 451, an egg just deposited on *Lemna*; 452, an egg with the young vibrating; 450, the young one just escaped from the shell; 453, the teeth separately.) Length of lorica 1-144″.

S. *spinigera*.—Lorica with four frontal and three posterior horns; the posterior dorsal one longest, and a little recurved. Among *Ceratophylla*. Length of lorica 1-140″ (XXXVIII. 23, 24).

S. *ventralis*.—Lorica stippled, horns two in front, three behind, the dorsal one short and decurved. According to Perty, a faint lens seen in the eye. Amongst Confervæ, &c. 1-120″.

S. *redunca*.—Lorica smooth, horns two in front, three behind; two of the latter (the under ones) hooked, the dorsal crest bifid and gaping; teeth four to each jaw. Amongst Confervæ. 1-200″.

S. *brevispina*.—Lorica milky and turbid, but appearing bright; scabrous, horns two (small) in front, and three behind, short dorsal crest not gaping; respiratory tube unknown. Amongst *Ceratophylla*. 1-144″.

S. *bicarinata*.—Lorica smooth, horns four in front, three behind, short; neither lateral muscles nor respiratory tubes known. 1-216″.

S. spinigera, *S. ventralis*, *S. redunca*, and *S. bicarinata* are probably slightly variable forms of one and the same animal.

S. *mutica* (Perty).—Lorica toothless both in front and behind, truncate posteriorly with obtuse angles. Transparent. Eye red. Tail-flaps extend to the root of the tail.

Genus DINOCHARIS (XXXIV. 454–456).—Eye single, cervical; foot furcate; lorica closed below, with a sharp lateral margin, but unarmed at both ends. The compound rotary organ has five or six muscles, and in two species the foot two. An œsophageal bulb, with single-toothed jaws, is found, except in *D. tetractis*, which Ehrenberg thinks has four teeth; œsophagus very short, alimentary canal constricted; two oval glands exist in *D. Pocillum* and *D. tetractis*. An ovary is seen in all, and a contractile vesicle at the base of the foot in *D. Pocillum*. Traces of a water-vascular system are perhaps to be seen in *D. Pocillum*, though even here it is doubtful, for the apparently tremulous organ just behind the œsophagus may be only a tremulous condition of an internal fold of the stomach. The only evidences of a nervous system are the eye and the long ganglion which supports it.

DINOCHARIS *Pocillum* (*Trichoda Pocillum*, M.).—Lorica nearly cylindrical, with a slight dorsal ridge; two long spines at the base of the foot, toes three. (XXXIV. 454, 455 represent this creature in different positions; and 456 the œsophageal bulb.) Amongst *Ceratophylla*, &c. 1-120″.

D. *tetractis*.—Lorica acute, triangular; horns two, at the base of the foot; toes two. This species has longer toes than the others; and the body is comparatively shorter. With Lemnæ and *Ceratophylla*. 1-120″.

D. *pauper*.—Lorica acute, triangular; horns two, at the base of the the foot, scarcely perceptible; toes two, short. 1-120″.

Genus MONURA (XXXIV. 457–459).—Eyes two, frontal; foot simple, styliform. The lorica is somewhat compressed and open upon the ventral surface: anteriorly is a hook-like process, which can be withdrawn. In one species, the vibratile organ has four to six muscular bulbs; in both, an œsophageal bulb, with two-toothed jaws, a very short œsophagus, and a simple alimentary canal with two spherical glands are observed; an ovarium, with a single large ovum, has been seen. The eyes are red, moveable, and seated upon nervous masses. The species are not only difficult to distinguish from each other, but also from the genus *Colurus*,—the toes of the latter appearing single until pressure is used.

MONURA *Colurus*.—Lorica oval, obtuse, obliquely truncated posteriorly, eyes near to each other. Lorica 1-280″. Siberian specimens 1-400″.

M. *dulcis*.—Lorica ovate, anteriorly acute, posteriorly obliquely truncate; eyes distant from each other; the alimentary canal is often filled with green matter. They increase rapidly in glass vessels. (XXXIV. 457–459 represent three views of this animal.) Amongst Confervæ. Length of lorica 1-288″.

The two species of *Monura* are referred by Dujardin to *Colurus*, or, to adopt his appellation, to *Colurella*.

Genus COLURUS (XXXIV. 460–462).—They have two frontal eyes, a furcate foot, and a compressed or cylindrical lorica. The lorica is said to be open upon the under side (*scutellum*); a compound rotary organ is present in all, over which projects a retractile frontal hook; an œsophageal bulb with two jaws, in two species with two or three teeth; the œsophagus very short; two species have a constricted stomach (Gasterodela), the others have a simple alimentary canal (Cœlogastrica), all with glands. The two red frontal eyes are delicate; in *C. uncinatus* and *C. bicuspidatus* they have escaped observation; all have peculiar vesicles at the back. They resemble *Monura.* Foot furcate.

Colurus (?) *uncinatus* (*Brachionus uncinatus,* M.). — Lorica ovate, compressed; posterior and bi-pointed toes, very short; at the middle of the back is generally a circlet of vesicles, which at one time Ehrenberg considered eyes, but which he now regards as vesicles of oil, as they are seen in all the species, and abundantly in the Cyclopida. In fresh and sea water. 1-430″ to 1-288″.

C. (?) *bicuspidatus.* — Lorica ovate, compressed; the two points posterior, strong; toes short. 1-288″.

C. *caudatus.* — Lorica ovate, compressed, posterior points distinct; toes longer than the foot. The shell resembles *C. uncinatus,* but the toes are much longer. In fresh and sea water. Lorica 1-288″.

C. *deflexus.*—Lorica ovate, compressed; the shell is more rounded, and very transparent. (xxxiv. 460–462 represent back, under, and side views; the former shows the vesicles.) In the clear water of a peaty moor. 1-240″.

Genus METOPIDIA (XXXIV. 463–465).—Eyes two, frontal; foot furcate; lorica depressed or prismatic; the frontal portion naked or uncinate, not provided with a hood; indeed they may be regarded as *Lepadellæ* with two red frontal eyes; the lorica, which is oval and semicircular or crescentic in front, appears to be closed on the under side (*testula*). In two species the rotary organ has from three to four muscles; and in one species two foot muscles are observed. Two species have a frontal hook, like *Colurus.* The œsophageal bulb in one species has two, in another four, but in the third no distinct teeth; a short œsophagus and two spherical glands are present in all. Two species have a distinct constricted stomach (Gasterodela). An ovary is present; and *M. triptera* has a contractile vesicle. Eye, according to Leydig, with a lens.

Metopidia *Lepadella.* — Lorica depressed, nearly flat, broadly ovate, excised in a lunate manner in front, rounded posteriorly; toes somewhat longer than foot. This species resembles in form *Lepadella ovalis* (xxxiv. 430–433) and *Squamella Bractea*; but the former has two-toothed jaws and no eyes; the latter, four eyes and indistinctly-toothed jaws. (xxxiv. 463–465, back, under, and side views, the first and last having the rotary organs extended and in motion.) 1-240″.

M. *acuminata.* — Lorica depressed, nearly flat, oval in shape; anteriorly slightly excised, posteriorly pointed. This species resembles *Colurus*; but in that genus the eyes are very close together, and the lorica open beneath. Amongst Oscillatoriæ. 1-240″.

M. *triptera.*—Lorica oval, triangular, back crested: a section would resemble xxxiv. 443. Amongst Confervæ. 1-200″.

M. *solida* (Gosse). — Much resembles *M. Lepadella,* but is considerably larger; lorica circular, brilliantly transparent; a slight punctation surrounds the edge, like that on a coin. Lorica 1-150″.

M. *oxysterna.*—Resembles *M. triptera,* but the dorsal keel is much higher and thinner; the anterior two-thirds of the ventral surface form a prominent ridge, terminating abruptly like the breastbone of a bird; and the posterior portion is hollowed out remarkably. Viewed laterally, the outline of the back is very gibbous behind. Lorica 1-175″.

Genus STEPHANOPS (XXXIV. 466, 467; XL. 8–10). — Eyes two, frontal; foot furcate; lorica depressed or prismatic, the front expanding into a hood or transparent shield. The lorica, in two species, has thorn-like processes posteriorly. In one species a longitudinal muscle is observed on each side (anteriorly), two muscles for moving the foot, and from three to five belonging to the compound rotary organ. The œsophageal bulb has single-toothed jaws, and a short œsophagus. In one species the alimentary canal is constricted, in the others it is simple; two species have glands; an ovary exists in all; a contractile vesicle in two. The red eyes are situated on each side, near the frontal head in two species; in one they are yet unknown.

The hood remains extended, even when the creature withdraws within its shell (XL. 8–10).

STEPHANOPS *lamellaris* (*Brachionus lamellaris*, M.).—Lorica with three spines posteriorly. The rapid movement and transparency of this animalcule renders its organization difficult to observe. A process extends upwards from the oral opening and diverges into two filamentous appendages. Leydig affirms that the eye has a distinct hemispherical lens, and that the alimentary canal is divisible into maxillary bulb, stomach, and intestine. The two latter ciliated. Also a contractile vesicle present. (XXXIV. 466, 467, different views with the crystalline hood or diadem. This hood is often much larger than is represented in Ehrenberg's figures.) Amongst Conferva. Length of lorica about 1-300″.

S. (?) *muticus* (XL. 8–10). — Lorica unarmed posteriorly, entire. Two eyes, red. Head and tail larger in proportion to the trunk than represented by Ehrenberg. 1-144″.

S. *cirratus* (*Brachionus cirratus*, M.). —Lorica with two spines posteriorly. This species has a contractile vesicle. 1-240″.

Genus SQUAMELLA (XXXIV. 468, 469).—Eyes four, frontal; foot furcate. The lorica is closed (*testula*); the rotary organ consists of five or six muscular bulbs. In one species the œsophageal bulb has jaws, with two or three teeth each; its tube in one is short, in the other long and bent like the letter S. Both have a bipartite intestine (Gasterodela), with small glands; also an ovary and contractile vesicle. The eyes are disposed in pairs on each side the brow.

SQUAMELLA *Bractea* (*Brachionus Bractea*, M.). — Lorica depressed, broadly ovate. It is very transparent; the toes thick and short, not evident. Length of lorica 1-144″.

S. *oblonga*.—Lorica depressed, either elliptical or ovato-oblong, hyaline; toes long and slender; eyes larger than in the foregoing species. (XXXIV. 468, 469 represent back and side views of this animalcule.) In green-coloured water, with *Chlamydomonas Pulvisculus*. Length of lorica 1-280″.

Genus NOTOGONIA (Perty).—Body covered by a lorica which dilates posteriorly; posterior margin occupied by two pointed processes on each side, the shorter one being directed backwards and the larger one outwards. Two eyes widely separated, on the outer margins of the anterior extremity. Jaws curved, strong, with two or three teeth. Caudal setæ strong and bristle-like.

NOTOGONIA *Ehrenbergii*. — Slightly ventricose, grey. Rotary organ composed of a single row of cilia; eyes very small, pale red. Length, including the tail, 1-14‴. Motions rather brisk, resembling those of *Brachionus*. Amongst Conferva.

FAMILY VII.—PHILODINÆA.

This family comprehends Rotatoria devoid of lorica, but possessing two simple rotary organs, resembling wheels. The body of most species is worm-like, or spindle-shaped (fusiform). Portions of the body can be thrust in and out, like the tubes of a telescope; this is effected by a sort of false joint, caused by a peculiar insertion of the muscles. In all the species the foot is furcate; and in *Callidina*, *Rotifer*, *Actinurus*, and *Philodina* it is provided with soft processes, near the false joints, resembling horns in shape, as in the genus *Dinocharis* (fig. 455). Muscles are seen in the genera just named.

The nutritive apparatus consists of an œsophageal bulb, with two jaws; in three of Ehrenberg's genera these are double-toothed (Zygogomphia); in two the teeth are in rows (Lochogomphia). In the four principal genera the alimentary canal is filiform; it is furnished with a bladder-like expansion at its commencement (Trachelocystea), and surrounded by a turbid cellular or glandular mass. In one genus the alimentary canal is conical (Cœlogastrica), in the two African genera its character is unknown. In four genera the intestine has glands; in a like number an ovary and glands are present; a contractile vesicle exists only in *Rotifer* and *Philodina*, which, together with *Actinurus*, are also sometimes viviparous. In *Rotifer* and *Philodina*, portions of a muscular system are visible, in the form of from nine to twelve transverse bands; the same genera, as also *Actinurus* and *Monolabis*, have spur-like tactile tubes. In thirteen species red eyes are present; and beneath these organs, only what is supposed to be nervous matter is apparent.

For Ehrenberg's arrangement of the genera, see General History, p. 479.

"The characters employed," says Dujardin, "by M. Ehrenberg, for the distinction of his genera of Philodinæa, have certainly too slight a constancy to be admitted; that author has himself seen the red specks, which he calls eyes, vary in number and position in his Rotifers. As to the appendages of the tail (toes), they are not always alike visible, although actually present, because the animal does not extend them except at certain moments; the central terminal appendage—that by which the Rotifers affix themselves to solid bodies—is itself of greater or less length, but always present. We therefore think that but two genera can be rightly established: one, *Callidina*, characterized by the feeble development of its ciliated rotary organ, and by entirely wanting red specks; the other, *Rotifer*, with two or several red points placed more or less near the exterior extremity, and, what is of more importance, with very highly developed rotary organs."

"The genera *Hydrias* and *Typhlina* are founded on imperfect observations made by the author during his journey in Egypt; and the genus *Monolabis* ought to be placed elsewhere."

The family Philodinæa thus formed is arranged parallel with Brachionæa, as though the absence of a lorica were the only difference between them.

So far as Dujardin accepts of the same species, his family Rotifera and that of Philodinæa of Ehrenberg correspond.

The amazing persistence of vitality in the *Rotifer vulgaris* gives a great interest to this family, as also the occurrence of some of its members within the cells of aquatic plants. Dr. Morren's observations probably explain some of the latter occurrences; but it is a question whether recent discoveries in vegetable physiology may not further explain the existence of these animals within closed vegetable sacs. For instance, the origin of some cells by the vacuolation of *a soft penetrable protoplasm* suggests the possibility that the Rotifera may deposit their eggs within the soft, half-organized protoplasm; and in the process of vacuolation some of these ova might readily find their way into the vacuoles about to be converted into cells, the latter change being completed before the embryonic animalcule escaped from its ovum; and when it did so emerge, the completion of the vegetable process would cause the animal to find itself imprisoned within the walls of a vegetable cell.

Genus CALLIDINA (XXXIV. 470–473).—Distinguished by possessing a proboscis, and a foot furnished with processes resembling horns, and by the absence of eyes. The vibratile or rotary organ, is double, not pedicled, and is surmounted by a thickly ciliated proboscis. The furcate foot has two elongated toes, four little horns or processes, and six points. Muscles for moving the foot are also visible. The œsophageal bulb has two jaws, with numerous delicate teeth. The filiform alimentary canal has a bladder-like expansion posteriorly, but is not provided with glands: it is surrounded by a granular and cellular mass, whose function is unknown; Ehrenberg thinks it connected with reproduction. An ovarium, with single large ova, is seen. A little spur-like process projects from the neck. No indication of a nervous system is observable.

CALLIDINA *elegans.*—Spindle-shaped, crystalline; rotary organs, or wheels, small. (XXXIV. 470–472; 473, the eggs.) In bog-water and infusions of oak-bark. 1-72″.

C. *rediviva* (Ehr.).—Fusiform, diffusely granular or else fleshy; with red, distinct ova, and strong rotary organs. 1-60″ to 1-48″; ova 1-576″. Berlin; in the sediment of water-spouts of houses.

C. *cornuta.*—On each side of the head a short horn-like process. Maxillary bulb much wider behind than in *C. elegans.* Ciliary motion unusually strong in the œsophagus. Swims in rather an eel-like manner. *C. constricta* (Duj.), so named on account of the contracted form of its rotary apparatus. Its jaws present a row of closely-set parallel teeth. 1-52″.

C. *bidens* (Gosse).—Body spindle-shaped, jaws furnished with two distinct teeth. 1-45″. Perhaps this is no other than *C. elegans*, the jaws of which Ehrenberg describes as having many delicate teeth. I have, however, examined numerous specimens, and have always found them distinctly two-toothed.

Genus HYDRIAS (XXXV. 474).—It is devoid of eyes, proboscis, and the little horn-like processes at the foot; the two small rotary organs, or wheels, are supported on pedicles or arms.

An œsophageal head, and an ovary, with a large ovum, have been seen by Ehrenberg. The form is like a naked *Pterodina*. This genus is constructed for an African Rotatorian imperfectly observed.

HYDRIAS *cornigera.*—Ovate, hyaline; foot attenuated, resembling a furcate tail. XXXV. 474 represents an animalcule extended. With Oscillatoriæ, in standing water from a small spring at Siva, in the Oasis of Jupiter Ammon. 1-190″.

Genus TYPHLINA (XXXV. 475).—Like the last, is an African form. Devoid of eyes, proboscis, and horn-like processes at the base of the foot; but its little wheels are sessile. It resembles a very small *Rotifer*, without frontal proboscis or eyes.

TYPHLINA *viridis.*—Body oblongo-conical, small (XXXV. 475). Found by Drs. Hemprich and Ehrenberg in a pool near Cairo in Egypt, in such numbers as to colour the water green. 1-720″.

Genus ROTIFER (XXXV. 476–480; XXXVIII. 1–3).—Body fusiform. Able to retract and protrude its little foot with its appended horns. Eyes two, placed upon the frontal proboscis; foot provided with little horn-like (corniculate) processes, and two toes bisulcate at their apices. A double rotary organ, furnished with muscles, is seen in all the species; also longitudinal and foot muscles in three of them; a furcate foot and horn-like processes in four species; in *R. citrinus* the pincer-like portions of the foot appear to be tri-pointed; in *R. erythræus* they seemed to be drawn in. In four species a muscular œsophageal bulb, with jaws, each two-toothed, is seen; in three species the alimentary canal is filiform, with a vesicular expansion at the extremity, but no œsophageal tube; it is moreover surrounded by a cellular glandulose turbid mass; another species has a conical, tubular alimentary canal, without the surrounding mass or expansion at the end; the four European species have two spherical alimentary glands, and an ovary, with a few large ova; occasionally these species are viviparous. In three of them a contractile vesicle is present. In *R. macrurus*, near the alimentary canal are two glands. In three species from nine to twelve parallel transverse muscular bands have been observed; and besides these, in the four European species, styliform tubes emanate from the neck, which in one species are ciliated anteriorly. Two red frontal eyes are met with in the four European forms, and beneath them, in *R. vulgaris*, two ganglia.

ROTIFER *vulgaris* (*Vorticella rotatoria*, M.) (xxxv. 476–480). — Body fusiform, white, gradually attenuated towards the foot; eyes round. This creature, which was discovered by Leeuwenhoek, was described and illustrated in the *Microscopic Cabinet* some years ago, prior to the appearance of Ehrenberg's observations. "It has the power of contracting or extending the length of the body in the following remarkable manner: — When the creature is about to shorten itself, transverse folds or joints are observable, which do not appear to be confined in number or situation; the integuments, when a joint is produced, are drawn within the parts above, and slide out like the tubes of a telescope, when the joints disappear. It is this power that enables it to assume the form of a sphere, the head and tail being drawn within the body." Anteriorly it has a proboscis-like process, with a ciliated extremity, and a soft hook, near which are two dark red points. The body terminates posteriorly in a moderately long tail-like foot, having six processes disposed in pairs; two wreaths of cilia (the wheels), voluntarily moveable, are placed upon short thick arms (pedicled), which can be drawn in and out at pleasure; these wreaths serve for swimming and purveying, the food approaching the mouth through the currents produced in the water by the cilia. On the dorsal surface is a styliform horn (*speculum collare*, M.), at the end of which Leydig detected retractile cilia. During vibration the neck has a circular fold, which appears on each margin in a front view like a lateral style. Four longitudinal muscles, two anterior and two posterior, are seen; laterally also two, club-shaped, for moving the foot, and two belonging to the rotary organ. Sometimes, says Ehrenberg, four anterior longitudinal muscles and a dorsal and ventral muscle appear to be present. It has two kinds of locomotion,—one by alternately attaching the mouth and foot, and, as it were, stepping along; the other by swimming, through the rotary apparatus. If the creature attach itself by the foot, and the rotary apparatus be in motion, a strong current or vortex is produced on each side the wheels, resembling two spirals in the water, which bring the nutritive particles to the mouth, from which some are chosen and the rest flow away. In order to observe this action with effect, finely-divided carmine or indigo must be mixed in the water. The oral aperture is placed just beneath the hook-like proboscis, from whence it continues backwards as a long extensible tube, as far as the œsophageal head, which has four muscles and two striated jaws with double teeth (Zygogomphia). From this point a filiform intestinal canal extends posteriorly, forming an oval expansion near its termination at the anus, at the base of the tail-like foot. A thick glandular cellular mass, often yellowish or greenish, surrounds the alimentary canal; its use is unknown: anteriorly are two biliary glands. The propagative system is very interesting: the ovary is a globose glandular mass; in it four or five ova sometimes so completely develope themselves that the young creep out of their envelopes, extend themselves, and put their wheels in motion while within the ovary; they sometimes occupy two-thirds the length of the parent. In the ovum the young are coiled up in a spiral manner. A contractile vesicle exists, and eleven or twelve parallel transverse bands, probably muscular. The two red frontal eyes, with a ganglion beneath them, indicate a nervous system. These eyes are cells filled with a granular pigment, and sometimes separate abnormally into several; Leydig affirms that they contain a refracting body. (xxxv. 476, a full-grown animal extended, and supposed to be attached to a fixed body—the currents about the trochal disc as displayed when indigo is put in the water; 477, an under view, the wheels withdrawn, and body contracted; 478, an extended *Rotifer*, wheels withdrawn; 479, 480, upper portions more highly magnified, after submission to different degrees of pressure between the plates of a compressor. In xxxv. 476–478, ova are seen; some are developed, and their eyes and œsophageal bulb visible. The transverse muscles, and the tube projecting from the neck, are seen in the engravings. Found in fresh and sea-water, in infusions, on the flocculent matters of water-plants, and even within the cells of some, *e. g.* of *Sphagnum* and *Vaucheria*, &c. (See Part I. p. 466.) 1-50″ to 1-24″.

R. (?) *citrinus*.—Fusiform, lower part gradually attenuated into a foot; its horn-like processes elongated; eyes round and, according to Leydig, containing a refracting body; cervical tube toothed. The extremities are transparent, the middle of the body of a citron colour; it often exhibits longitudinal folds, and is then less transparent. Amongst Oscillatoriæ. 1-24″.

R. (?) *erythræus*. — Small, oblong, suddenly attenuated into a long foot. 1-240″.

R. *macrurus* (*Vorticella macrura*, M.). — Transparent, ovato-oblong, suddenly attenuated into a long foot; this is distinguished from *Actinurus* by its small toes, horn-like processes, and suddenly-attenuated body. The style, or antennal tube, is ciliated in a star-like manner. The wheels are prominent. A long stomach is succeeded by a short intestine; on each side is a convoluted water-vascular canal, but without vibratile tags. Eyes either two, hemispherical, abruptly truncate anteriorly, red, and with a refracting medium, or elongated posteriorly, becoming divided into several rows of linear points, without refracting media. It is altogether a choice subject for the microscope. In boggy water. 1-350″.

R. *tardus*. — Hyaline, fusiform, gradually attenuated to the foot, and having deep strictures in the form of square false articulations or joints; eyes oblong. It resembles internally *R. vulgaris*. 1-80″.

Of the several species of *Rotifer*, and of the following one of *Actinurus*, described by Ehrenberg, M. Dujardin confesses his inability to discover the specific differences, although he admits diversity of habitat, and of resistance to the process of desiccation. He, however, believes he has discovered a *Rotifer* specifically distinct from any variety of *Rotifer vulgaris*; this he would designate

R. *inflatus* (xxxviii. 1–3).—It is less slender than *R. vulgaris*, its rotary organs of less size, and its red specks seated very near the jaws. 1-58″. In water or wet moss.

Of this species Dujardin infers that Ehrenberg has constructed at least four others, according to the rose or yellow colour it presents, the form of the eyes, and the length of the caudal appendages, viz. *Philodina eryophthalma*, *P. roseola*, *P. citrina*, *P. macrostyla*. At the same time he would regard *P. collaris*, *P. megalotrocha*, and *P. aculeata* as distinct forms of Rotifera.

R. *macroceros* (Gosse).—Wheels large; antennal process (the respiratory tube, Ehr.) very long and mobile. 1-100″.

Genus ACTINURUS (XXXV. 481–484).—Eyes two, frontal; foot furnished with two little horn-like processes, and three toes. In other respects the organization resembles *Rotifer vulgaris*.

Actinurus *Neptunius* (*Vorticella rotatoria*, M.).—White, fusiform, gradually attenuated into a long foot, having three equal toes exceeding the horn-like processes in length. The action of the jaws in the œsophageal head is often distinctly seen. (xxxv. 481, an animal extended, with the wheels withdrawn, which is the case when crawling; the antenna is then seen, terminated by a single delicate hair-like point; 482, contracted, head partially withdrawn; 484, the upper part, when the wheels are extended and in action; 483, the œsophagus and jaws, separated and extended under pressure.) 1-36″ to 1-18″.

Genus MONOLABIS (XXXV. 485, 486).—Eyes two, frontal red; foot with two toes, but no horn-like processes. They are provided with muscles for moving the double rotary apparatus, two for moving the foot, and four belonging to the œsophageal bulb and jaws, which last are furnished with double teeth, or teeth in rows. A very short œsophageal tube and a simple conical alimentary canal are seen in both species; one of them has two spherical glands; an ovarium is seen in both, but in neither have fully-developed ova or male organs been observed. In one species, a tactile tube is present.

MONOLABIS *conica*.—Stout, provided with a tactile tube, or spur, and three teeth in each jaw. Between the rotary organs the brow can project and resemble a proboscis. (XXXV. 485, 486 represent different views from the under side.) 1-120″.

M. *gracilis*.—Has a more slender body than the last, and two teeth in each jaw, but no tube or spur. Length about 1-200″.

Genus PHILODINA (XXXV. 487–490; XXXVIII. 4).—Eyes two, cervical, foot with horn-like processes. All the species possess two vibratile or wheel organs upon the breast, and five of them have a frontal ciliated proboscis. Longitudinal muscles are distinct in one species, and two for moving the foot in six. The œsophageal bulb has four muscles; its jaws are two-toothed in four species, three-toothed in two species; but in one species the œsophageal bulb has not been satisfactorily seen. The alimentary canal is filiform, with a posterior enlargement in six species; in one it appears to have pouches or pockets. The glandular or cellular mass surrounding the filiform part of the canal sometimes becomes distinctly coloured when the creature eats coloured food, and therefore seems connected with the nutritive system, and is probably a convolution of cæcal appendages. Biliary (?) glands are found in six species. The ovary developes eggs, which are usually extruded before the young are hatched. Three species possess a contractile vesicle; one, vibratile tags. A tube, in some cases ciliated, is always present at the neck. Transverse bands are seen only in *P. erythrophthalma*. Eyes are found in all the species, and nervous ganglia connected with them in *P. erythrophthalma*: sometimes the eyes are very pale; hence a solitary specimen may be mistaken for a *Callidina*. XXXVIII. 14 is a diagram of the head of *Philodina* as viewed in front, and fig 15 of the same viewed laterally.

PHILODINA *erythrophthalma* (XXXVIII. 4).—White and smooth; eyes round; horn-like processes of the foot short; jaws two-toothed. Found abundantly during the spring and summer in water-tubs and amongst Confervæ. In glass vessels it increases rapidly; and, if supplied occasionally with two or three stems of hay, the breed may be preserved for years. It is often met with in vegetable infusions of different kinds. 1-120″ to 1-48″.

P. *roseola*.—Body smooth; eyes oval, horn-like processes of the foot short. "I have observed," says Ehrenberg, "that this animalcule, when kept in glasses, deposits its eggs in heaps, and the parent remains a long time with the young ones produced from them, forming a sort of family or colony, which circumstance we are not to be hindered from ascribing to a *sense of company or family*, though the pride of man may laugh at it." (XXXV. 490 represents one with the wheels extended.) 1-72″ to 1-48″.

P. *collaris*.—Body smooth, hyaline, or white, eyes round; a prominent annulus or collar surrounds the neck. It is especially characterized by the extent of the alimentary canal, and cæcal appendages attached to it; so that, when the animalcule is fed upon indigo, it appears polygastric. 1-120″.

P. *macrostyla*.—White and smooth, with oblong eyes; it has three teeth in each jaw; horn-like processes of the base of the foot long. Found amongst Oscillatoriæ. 1-70″.

P. *citrina*.—Smooth, citron-coloured in the middle; extremities white; eyes variable in form; horn-like processes slightly elongated. Found amongst Oscillatoriæ. 1-70″.

P. *aculeata*.—White, provided with soft spines; eyes round. The tactile tube (antenna) is thickened anteriorly in a globose manner; the jaws have each three teeth. (XXXV. 487, 488 represent this animalcule; and 489 the jaws and teeth separate.) 1-70″.

P. *megalotrocha*.—White; body smooth and short; wheels large; the proboscis between them long; eyes oval; jaws two-toothed. Two straight setæ at the end of the tail. 1-216″ to 1-108″.

P. *hirsuta*. — Of a pale yellow colour, and covered with a short down; eyes oblong; foot prolonged by dorsal spines; viviparous. Length 1-72″; of egg 1-480″. Berlin.

FAMILY VIII.—BRACHIONÆA.

The concluding family of the Rotatoria, BRACHIONÆA, is distinguished by its members having two rotary organs and a lorica.

The lorica is open at the extremities, like a tortoise's carapace. The rotary apparatus is often apparently composed of five parts, three central and two lateral; of which the latter alone belong actually to it, the others being only ciliated frontal portions, which during the vibration of the trochal disc remain stiffly extended as feelers. Besides these appendages, the disc presents in most, perhaps in all the species, two setæ, as is seen also in *Synchæta*. The genera *Noteus* and *Brachionus* have a forked foot, *Anuræa* is destitute of feet; and *Pterodina* has a suctorial disc at the end of the foot, but no toes. All the genera have jaws, with teeth attached to an œsophageal head, having four muscles. In *Pterodina* the jaws are partly two-toothed and the teeth in a line (*zygogomphia, lochogomphia*), in the other genera they are many-toothed (*polygomphia*). In *Noteus* and *Pterodina*, the alimentary canal is constricted, forming stomachs (*gasterodela*); in the rest it is partly simple (*cœlogastrica*), partly with stomachs. Glands have been observed in all the genera, as also an ovary and contractile vesicle. Many species of *Anuræa*, *Brachionus*, and *Noteus*, carry their eggs attached to them, after expulsion. In all the genera, except *Pterodina*, internal tremulous tags attached to the water-vascular canals have been observed. A nervous system is supposed to be indicated by the presence of red visual points in all, except *Noteus*, which, however, possesses what is believed to be a cerebral ganglion.

Some of the Brachionæa may become so numerous as to render the water milky and turbid.

Ehrenberg's classification of this family is given at p. 479.

It was amongst the Brachionæa that some of the most interesting of recent investigations were first made by Perty, Cohn, and Leydig. Thus, striped or voluntary muscles have been noticed in *Brachionus militaris* by Cohn, and in *Pterodina* by Leydig; whilst, in the latter case, the same distinguished observer alleges that he finds a refracting body in the eye similar to what he had detected in *Euchlanis* and *Stephanops*. In *Brachionus urceolaris* and *militaris*, again, Perty and Cohn have established the existence of diœcious sexuality amongst the Rotatoria—the male animal, as in the previously described diœcious forms, being devoid of an alimentary canal; and to this list Mr. Gosse has since added *B. Pala*, *B. rubens*, *B. amphiceras*, *B. angularis*, *B. Dorcas*, and *B. Mülleri*. Its rarity, and the comparatively short period of time during which, according to Perty, the male animalcule of *Brachionus urceolaris* exists, probably explain why these creatures have been so long overlooked. Cohn observed that the contractions and expansions of the contractile sac at the base of the water-vascular canals of *Brachionus militaris* were accompanied by a corresponding motion in their watery contents. At each contraction, or systole, a stream was expelled into the cloaca, communicating with the water in which the creature lived, whilst an opposite movement attended the expansion or diastole of the sac. These facts strongly corroborate the supposition that the water-vascular canals are the true respiratory organs of the Rotifera, corresponding with the remarkable analogous organs arising from the cloaca of the *Holothuriæ* amongst the radiated animals; the pure oxygenated water being thus carried to the fluid distending the body, which fulfils the functions of the blood in higher animals, and affording an example of the "Phlebenterism" of the French naturalist Quatrefages.

In *Brachionus militaris*, Cohn has also pointed out the existence of three distinct classes of eggs—viz. winter, summer, and male ova—all differing in their form and aspect.

Genus NOTEUS (XXXV. 491–494; XXXVIII. 25).—Eyes absent; foot furcate (*Brachioni* wanting eyes). The two-wheeled trochal disc has between its portions a three-lobed ciliated brow, but has no long bristle-like feelers; it possesses (as also does the furcate foot) distinct muscles. The lorica has spines both anteriorly and posteriorly; an œsophageal head with jaws having many teeth (*polygomphia*), a constricted alimentary canal or stomach (*gasterodela*) with two large glands, an ovarium, and a contractile vesicle are to be recognized. There is also a trace of tremulous tags, a short and thick water-vascular tube, and a large central ganglion, lying between the muscles of the vibratory organs. Dujardin considers the absence of eyes insufficient to constitute this a genus apart from *Brachionus*.

NOTEUS *quadricornis* (XXXV. 491–494; XXXVIII. 25). — Lorica suborbicular, depressed, rough and urceolated, with four spines anteriorly and two posteriorly. Rotary organ simple, with a deep oral fossa; three lobes on its free surface. Alimentary canal as in *Brachionus*. A contractile sac on the right of the cloaca giving off two canals, each bearing three tremulous tags; a short and obscure siphon between the large spines on the front of the body. This animalcule is large, very transparent, and of a whitish colour. (XXXV. 491-493 represent dorsal, ventral, and side views; and 494 the jaws separate, and under pressure.) Found amongst decayed sedge-leaves and Oscillatoriæ. 1-120″ to 1-72″.

Genus ANURÆA (XXXV. 495–498).—Brachionæa with a single cervical eye, but no foot (*Brachioni* without feet). In seven species the lorica has four longitudinal rows of facettes upon the back; in three it is smooth; in thirteen species it is spinous anteriorly, and in seven posteriorly also. *A. biremis* has a moveable spine on each side: of one species, only the empty shell has been seen; in the rest the muscles of the rotary organ, but not the longitudinal muscles of the body, have been observed. Jaws and teeth are seen in nine species. Alimentary canal constricted (*gasterodela*) in four; simple and conical (*cœlogastrica*) in nine. Two glands are placed at the commencement of the alimentary canal; an ovary is seen in twelve species, but a contractile vesicle only in one of the larger and smooth species, in which also four tremulous tags are found. In three species siphons emanate from the neck. The eye-speck, which is always present, is supposed to indicate the existence of a nervous system. In *A. squamula, A. curvicornis, A. biremis, A. striata,* and *A. foliacea,* what is thought to be nervous matter is seen below it. Eight species have their eggs attached to them after they are expelled. They swim freely, though not very quickly. This genus has the name of *Anourella,* given to it by Bory St.-Vincent, and retained by Dujardin.

a. *Species posteriorly devoid of spines and pedicle.*

ANURÆA (?) *quadridentata.*—Lorica oblong, with four horns anteriorly, its posterior end obtuse, back tessellated. 1-216″ without the horns.

A. *Squamula* (*Brachionus Squamula,* M.).—Smooth, obtusely square, with six horns in front, obtuse behind. (XXXV. 495–497 represent different views of this animalcule, the two latter with an egg attached.) 1-240″.

A. *falcata.*—Oblong; with six spines anteriorly, the two central of which are curved outwards, like sickles. Surface of the lorica not ridged, but rough; posterior extremity obtuse. 1-144″.

A. *curvicornis.*—Nearly square, with six frontal horns, the two middle ones larger and curved outwards and downwards. Dorsal surface tessellated; its large, red, round eye is seated upon a large nervous ganglion; the œsophageal bulb has three-toothed jaws. This animalcule also carries the eggs attached. 1-216″.

A. *biremis*.—Linear and elongated, with four horns anteriorly; back very smooth, and having two lateral spines, like oars. The œsophageal head has three-toothed jaws. In phosphorescent sea-water. 1-144″.

A. *striata* (*Brachionus striatus*, M.).—Linear and elongated, with six horns in front, and four on the abdominal surface of the lorica; the back with twelve longitudinal flutings or rays, and obtuse at the end. This species is very changeable in form, owing to the membranous lorica yielding to the contraction of the body: hence it is sometimes long, at others short, sometimes urn-shaped, bell-shaped, and even almost disc-shaped; the first, however, seems to be the normal form. In fresh and salt water. 1-130″.

b. *Spinous or attenuated posteriorly.*

A. *inermis*.—Lorica oblong, attenuated and truncated posteriorly; no spines anteriorly; back furnished with faint longitudinal rays. In peat-water. Length when extended, 1-144″.

A. *acuminata*.—Lorica oblong, attenuated and truncated at the posterior extremity, having anteriorly six sharp-pointed horns or spines, twelve longitudinal rays on the back. Amongst Confervæ. Length about 1-120″.

A. *foliacea*.—Lorica oblong, six spines anteriorly, posteriorly terminating in a spine; dorsal and ventral surfaces longitudinally striated; frontal region rough. It has four-toothed jaws, and a central ganglion below the eye. 1-180″.

A. *stipitata* (*Brachionus*, M.).—Lorica nearly square, or triangular; anteriorly six spines; posterior pointed like a pedicle; the back tessellated. (xxxv. 498 represents a dorsal view, with the wheels extended.) Length about 1-200″.

A. *Testudo*.—Lorica square, having anteriorly six straight spines, all of nearly the same length, and posteriorly a short one at each corner. The upper and under surfaces are rough, the former tessellated like *Noteus*. Length about 1-200″.

A. *serrulata*.—Lorica ovate, square, with six unequal spines anteriorly, the two middle ones long and curved; it has two short spines at the posterior angles, which are sometimes scarcely apparent. The surfaces are rough, and the dorsal also tessellated, like the preceding species. Independently of the two wheels, the brow has three cylindrical ciliated processes, which are truncate at their extremities. 1-216″.

A. *aculeata* (*Brachionus quadratus*, M.).—Lorica square, with six spines anteriorly, the two middle longest; at the posterior angles are two long and equal spines; back rough and tessellated, under side smooth. At the brow, between the two wheels, is a single ciliated frontal process; a little tactile organ is situated in front of the eye. Length 1-144″; including the spines, 1-96″.

A. *valga*.—Lorica nearly square, with six spines anteriorly, the two middle ones the longest; at each posterior angle is a spine of unequal length; dorsal and ventral surfaces rough, the former tessellated. The jaws are five-toothed, the red eye oval, its longer axis transverse. Length, without the spines, 1-210″.

The following species are given by Mr. Gosse (Ann. Nat. Hist. 1851, vol. viii.).

A. *fissa* (Gosse).—Lorica smooth, hyaline, swollen at the sides and at the back; flattish on the belly, truncate in front, without any spines, attenuated and truncate posteriorly. There is a deep fold running down each side, or else the ventral plate is distinct from the dorsal; the ventral is also cleft through its medial line; eye very large, pale. 1-220″.

A. *tecta* nearly agrees in form with *A. curvicornis*; but the posterior extremity is rather more pointed, and the tessellations are different, being larger, and arranged on each side of a medial dorsal ridge, which gives to the back the form of a vaulted roof. 1-200″.

A. *brevispina* nearly agrees with *A. aculeata*; but the posterior spines are very short, the frontal spines are much less curved forwards, the surface is not punctated, and it is colourless. 1-146″.

A. *cochlearis*.—Lorica spoon-shaped, with six spines in front, the medial pair curving strongly forwards; posterior extremity attenuated into a long slender spine, inclined forwards; back ridged and tessellated, as in *A. tecta*.

A. *heptodon*=*Ascomorpha Helvetica*, Perty.—Lorica of equal width, contracted posteriorly, and terminated by an upturned tooth in the middle line. In front are four teeth above and two below. 1-12″. This species, founded on one individual example, resembles *A. foliacea*, but is less flat, more cubical, and possesses the peculiar upturned tooth in the median line. (XXXVIII. 6.)

Genus BRACHIONUS.—Brachionæa which have a single cervical eye and a furcate foot. Figure compressed. Lorica closed at the sides; open at the extremities like a tortoise-shell. Anterior and posterior margins usually dentate; surface either smooth or rough and tuberculated, the tubercles on the abdominal surface arranged in four lines diverging posteriorly. The cuticle, which, according to Leydig, rests on a molecular layer, resists liquor potassæ. The frontal processes or teeth are dentate on their inner edge. Animal able to withdraw itself within the lorica. Rotary organ simple, and, though often looking as if lobed, presenting an unbroken border, except when it is indented by descending to the mouth, whence this bilobed aspect; a median lobe and two lateral ones arise from its free surface. On its right and left side are some eminences surmounted by long bristles, in addition to a long bristle projecting backwards from each lateral margin of the rotary organ. A granular mass, the supposed cerebral ganglion, supports the eye-speck, which is extended backwards into two points. A siphon, or tactile tube, terminated by a bunch of setæ, projects from between the anterior median teeth of the lorica. Two brown vesicles in front of the large muscular œsophageal bulb, in which are the toothed jaws; a short œsophagus; and a stomach, the latter composed of coloured cells, ciliated on their free surface. In front of the stomach two pedunculate glands. Intestine clear and ciliated. Contractile vesicle on the right of the cloaca, with two water-vascular canals proceeding from it to the neck, where they form a plexus and bear two tags. Ovary beneath the stomach. Eggs, according to Perty, of three sorts, viz. winter ova, summer ova, and ova bearing male embryos. Ova attached to the exterior of the animal. *B. Pala*, *B. urceolaris*, and *B. rubens* sometimes increase in such quantities as to render the water milky and turbid. Several species are infested with *Vorticella*, *Epistylis*, and other parasites, which attach themselves to their shells. Like *Asplanchna*, *Euchlanis*, and others, the genus *Brachionus* has acquired great additional interest from the discovery amongst some of its species of the distinct separation of the sexes. The male *Brachioni* present a different form to that of the female, resembling, in this respect, *Asplanchna Sieboldii* rather than *A. Brightwellii* and *Hydatina senta*, in which the difference of external contours is mainly one of size. The multiplying discoveries of separate sexes amongst the Rotifera, combined with the manifest absence of male organs in the numerous individuals provided with ovaries, renders it increasingly probable that all the Rotifera will finally be demonstrated to be bisexual or diœceous.

BRACHIONUS *Pala*. — Lorica smooth, with four spines in front, and two obtuse ones near the opening for the foot. Toes of the foot apparently bifid. This creature swims in a perpendicular position, the brow being directed upwards. Each jaw has five teeth; the alimentary canal being constricted, forms a stomach. Length 1-36″; lorica only 1-48″ (XXXIX. 14, 15).

B. *amphiceros*.—Has a smooth lorica, with four spines, in front and posteriorly; four sharp posterior teeth are characteristic. 1-72″.

B. *urceolaris* (*Brachionus urceolaris*, M.).—Whitish; lorica smooth, with six very short spines in front; posterior extremity rounded; lorica slightly granulated; its points are shorter and less sharp than in the following species; delicate longitudinal ridges proceed from the spines; the jaws have each five teeth.

The males of *Brachionus urceolaris*, according to Perty, are developed from smaller ova than the females, these eggs being also adherent to the parent in greater numbers. They are very spherical, reaching 1-50''' in length and 1-67''' in diameter. Their shell is more delicate and the contents clearer and more transparent, as well as of a pale yellowish hue instead of the dusky grey of the female ova. The former likewise contain fewer granules. The development by fission similar in both. When the egg is mature, it continues to be pale and transparent. The red eye-speck exhibits itself; but the maxillary apparatus, seen in the female ovum, is wanting. On the other hand, two or three heaps of dark granules occur, not seen in the females. The embryo escapes from the ovum by a transverse rupture, and is then seen to have a different contour from the female. It is but one-third the size of the latter, being, when extended, but 1-27''' to 1-22''' long, and from 1-60''' to 1-55''' broad. It is destitute of a firm lorica; short, cylindrical; prolonged anteriorly into a short head, separated by a constriction from the trunk; prolonged posteriorly into a short tubular foot about one-fifth the length of the body. Head crowned by a flattened disc, with a wide expanding margin, clothed with long vibrating cilia and a few non-vibratile bristles. Cilia moving with extraordinary velocity, preventing many being seen at once; but a little strychnine added to the water checks their action and facilitates their observation. No mouth is present; hence the ciliary wreath is not twined inwards at the oral fissure; the alimentary apparatus is wholly wanting. A large pyriform vesicular testicle, 1-100''' in length, occupies the middle of the body; it is filled with small dark moving spermatozoa. The wall of the testicle is very thick, and elongated at its upper extremity into a thick cylindrical band, which is attached to the cephalic disc. Posteriorly the testicle is striated longitudinally, and is perforated by an aperture opening into a wide spermatic duct conducting to the penis. The latter organ is a short tube usually laid free on the foot and nearly extending to its extremity; its internal canal and outer margin equally furnished with vibratile cilia. The foot is transversely wrinkled, and ends in two small toes. Near the root of the penis are two club-shaped glands which pour their secretion into its canal; near these is also a contractile vesicle with two water-canals and their appended tags. Several spherical cell-like bodies occur near the head,—the larger of these, the supposed cerebral ganglion, supporting the eye-spot. Two or three vesicles of uncertain character, filled with dark granules, rest on the testicle near its lower end. The males are much rarer than the females, and are not seen after the end of May. In fresh and brackish waters. Length of females from 1-96'' to 1-72''. (XXXIX. 10–20; XL. 20–23.)

B. *rubens* (*B. urceolaris*, M.).—Lorica smooth, with six sharp spines in front, posteriorly rounded; the body is red. 1-50''. Dujardin supposes this to be a variety of *B. urceolaris*. Leydig recognizes its distinctness. (XXXVIII. 7.)

B. *Mülleri* (*Müller's Brachionus*).—Lorica smooth, with six obtuse spines in front, two short ones behind, resembling papillæ. This species is somewhat larger than *B. urceolaris*, and has peculiarly-shaped frontal spines. The margin of the chin (brow) is smoothly truncate, with three faint indentations. The lorica is very transparent. 1-60''. According to Mr. Gosse, the *B. heptatomus* found in sea-water is identical with this species. (XXXIX. 13.)

B. *brevispinus*.—Lorica smooth, having six acute unequal spines in front, and four stout spines posteriorly, the two inner ones short; two sexual glands and a contractile vesicle are present. In slow running clear water, with Confervæ. 1-65''.

B. *Bakeri* (M.).—Lorica rough, its middle tessellated on the dorsal surface; six unequal acute teeth anteriorly, two elongated (lateral and dorsal) spines posteriorly, and short ones at the sheath of the foot. The lorica is covered with delicate granules; those upon the middle of the ventral surface are arranged in parallel but somewhat curved lines. 1-220'' to 1-60''. (XXXVIII. 8, 9, 10–17; XL. 16.)

"The following interesting observations as to the development of this species have been communicated to me by a friend, an accurate and diligent observer of nature:—About two o'clock *B. Bakeri* was observed with one egg placed externally between the two posterior spines of the shell, and another small egg in the left side of the animal, which increased much in size in the course of the day. At nine in the evening a motion was perceived in the exterior egg like that of the muscular œsophagus of the parent; and about this time the internal egg was protruded and placed by the side of the other, being longer than it. At eleven the young *Brachionus* burst with a bound from the egg in which the motion was perceived, and affixed itself by its tail to the lunette. At first it had the appearance of an oblong ball; by degrees the anterior part spread, and the wheel processes were developed. Soon after, the posterior shell-processes were visible in a semilunar shape, with the points nearly touching each other, which gradually expanded. The shell of the egg remained attached to the parent in the same position, quite transparent, with a longitudinal split through the whole length." (Brightwell, *op. cit.*)

B. *polyacanthus* (M.).—Lorica smooth, having anteriorly four long dorsal teeth or spines, six short ones at the margin of the chin (ventral), and posteriorly five dorsal spines, the two external or lateral ones very long. XXXV. 499–501 represent dorsal, side, and under views of this animal,—the first having the wheels extended, and the side view showing the siphon or so-called respiratory tube and an ovum attached. Length, without spines, 1-110″. XXXVIII. 14, 15 represent diagrams of the head.

B. *militaris*. — Lorica with surface divided into twelve regular pentagonal facettes, according to Cohn; its anterior border with several spinous processes; and posteriorly is a deep median excavation with a curved horn on each side. The spines, 10 in number (not 12 as affirmed by Ehrenberg), viz. 2 lateral, 4 abdominal, and 4 dorsal, the latter the largest; head larger than that of *B. urceolaris*, expanded in a funnel-shaped manner, surrounded by a circlet of cilia; its eversion is checked by the stiff spines of the lorica. Foot smaller and shorter than in *B. urceolaris*. Œsophageal bulb quadrangular. On each spine forming the outer posterior angle of the lorica is a circular pit with well-defined margin; from this proceeds a bunch of short bristles. Muscles of foot and head striped transversely. Contractile sac very large, occupying two-thirds of the abdominal cavity on the right side of the animal; it consists of two chambers, the ovate posterior one being the larger, their contractions being alternate; the posterior one opens into the cloaca by a short duct. On mingling coloured matter with the water, Cohn observed that on each systole or contraction a stream escaped from the sac, through the cloacal opening, and that on the diastole this movement was reversed, indicating a respiratory action. (XXXIX. 21, 22 represent the abdominal and dorsal surfaces of the female.) The ova are of three sorts:—1. Winter ova, 1-21‴ long, 1-33‴ wide, elliptic, with thick, leathery, opaque walls, the yelk not occupying the poles (XXXIX. 23); 2. Ordinary or summer ova, of similar dimensions, but with thin transparent walls; 3. Male ova, only 1-34‴ long and 1-42‴ broad (XXXIX. 24). Shell thin. Yelk subdividing in the usual way, and developing an embryo provided with a red eye, and two dark specks, but no maxillary organs. Cohn saw only one specimen freed from the egg, and that imperfectly. It appeared similar to the male of *B. urceolaris*.

B. *Oon* (Gosse). — Lorica ovate, the back swelling with a uniform curve, by which it is distinguished from *B. Pala*, which is truncate or slightly clavate posteriorly; anterior spines four, straight, wide at the base, and pointed; the occipital pair taller than the lateral. Lorica 1-125″.

B. *Dorcas*.—Lorica ovate or sub-conical; occipital edge with four long slender spines, the middle pair curving forwards, and bent first from, and then towards each other, like the horns of an antelope; mental edge undulated, with a notch in the centre. Lorica 1-60″. (XL. 11 represents a newly-born female, and fig. 12 a newly-born male.)

B. *angularis*. — Lorica in the female hexagonal-oval in the dorsal aspect; occipital edge with two small teeth, divided by a rounded notch (in some specimens there are obsolete traces of a lateral pair); mental edge slightly undulated, sometimes with two low points, divided by a notch like the occiput, but still more faintly; posterior extremity with two short, blunt, well-marked processes. The general surface is roughened with angular ridges, and is sometimes sub-opaque and brown. Lorica 1-200″. This curious species has relations with *Noteus* and with *Pterodina*. (XL. 19 represents a *male* of this species.)

Genus PTERODINA.—The winged Rotatoria include such Brachionæa as have two frontal eyes and a simple styliform foot projecting from the middle of the body. All the species have a smooth, flat, and soft lorica, like a tortoise-shell, with curved margins; as also a more or less double rotary appa-

ratus, and a simple foot with a suction-disc and sometimes a bunch of cilia at its extremity. *P. elliptica* has a hairy process projecting between the two lobes of the rotary organ, and *P. Patina* has a rounded prominence in a similar position on the dorsal surface. Muscles, often transversely striated, occur in all the species, as also a constricted alimentary canal with glandular appendages and an ovarium. Some have a contractile vesicle and a water-vascular system.

PTERODINA *Patina* (*Brachionus Patina*, M.).—Figure round, or oval compressed. Lorica membranous, crystalline, somewhat scabrous near its broad margin, and slightly excavated anteriorly between the two lobes of the rotary organ. The latter not double, as described by Ehrenberg, but with an anterior and posterior depression, from the latter of which extends a single rounded process. Cilia in two rows, prolonged to the œsophageal bulb. Stomach ciliated internally, widely expanded posteriorly. Short intestine also ciliated, and terminating at the base of the foot. Two pyriform glands in front of the stomach. Two red specks opposite the margin of the rotary organ; their red pigment has a sharp spherical figure; according to Leydig, an obvious refracting body projects from the anterior convex edge of each. Two large longitudinal muscles. On each side of the stomach a water-vascular canal, but without either tags or contractile sac. Ovary horseshoe-shaped. Free extremity of the foot with a bundle of setæ.

This animal was noticed by Perty to have the peculiarity of assuming an apparently lifeless state for half an hour or an hour at a time, lying in one spot, often on the surface of the water, with no other sign of life than that afforded by movements of the œsophageal cilia, and occasionally of the jaws.

This species is very delicate and transparent. XXXV. 502 represents a side view, and 503, 504 under views,—the latter having the wheels extended, the former having them withdrawn, and the anterior margin bent in, so that the eyes appear near the middle of the lorica. The internal organization is further shown in XXXVIII. 29. Found in summer among *Lemnæ* and *Ceratophylla*. Length about 1-120″.

P. *elliptica*.—Lorica membranous, elliptical, with a narrow, smooth margin, front entire (not excised). The two wheels united by a brow furnished with setæ. Eyes distant. Amongst Confervæ. 1-120″ to 1-108″.

P. *clypeata* (*Brachionus clypeatus*, M.).—Lorica membranous, oblong, narrow, smooth at the margin; there is a frontal portion, or brow, connecting the two wheels, but no setæ. The eyes approximate. (XXXV. 505 a dorsal view, with the wheels extended.) In sea-water. Length 1-120″; the shell 1-144″.

The next genus, *Pompholyx*, instituted by Mr. Gosse, is considered by him to be a member of this family.

Genus POMPHOLYX (Gosse, *A. N. H.* 1851, vol. viii.).—Two frontal eyes; foot wanting; rotary organ double in the rear, entire in front; eggs attached behind after deposition. The name alludes to the resemblance of the lorica to a round flat smelling-bottle.

POMPHOLYX *complanata*. — Lorica much depressed, nearly circular, with the lateral edges rounded; anteriorly truncate; occipital edge gradually rising to a central blunt point; mental ridge with two rounded lobes, divided by a central notch. Lorica 1-300″.

Of the ensuing genera, established by Ehrenberg, we have only met with the description of species; of one, indeed, with only a sketch of its relations.

Genus LARELLA (Ehr.).—The following species of this new genus, the characters of which we have not met with, is named by Ehrenberg.

LARELLA *Piscis*. — Body with equal setæ, and three long fine hairs placed on each side the mouth, with two frontal eyes.' Length 1-190″ to 1-280″. Berlin. Werneck has also seen this species.

Genus TETRASIPHON (Ehr.).—We have not met with the detail of the generic characters, but they may be gathered from the description of the following species:—

TETRASIPHON *Hydrocora.* Very large, hyaline, with two prominent tubular occipital organs, and other two near the termination of the back; pancreatic glands four, globose; jaws bidentate, with the oblique rotary organ of *Pleurotrocha.* Foot with slender, long and acute toes; eye occipital. Length 1-36″ and upwards. Berlin.

Genus DIPODINA.—Characters unknown.

DIPODINA *Artiscon* (Ehr.) (Mentioned in Reports of Zoology, Ray Society).—Approaches *Notommata,* but differs by a particular constriction of its tarsal nippers (toes). Found by Ehrenberg at Wismar, on the Baltic.

The genus POLYCHÆTUS (XXXVIII. 31, 32) of Perty is supposed by Leydig to be a Crustacean. CYPHONAUTES is also regarded by the same observer as dubious; whilst, as we have already observed, he regards *Ptygura* and *Glenophora* as undeveloped forms of other species.

OF THE GROUP TARDIGRADA.

THE creatures thus named are introduced here as a group, inasmuch as they cannot be included amongst the Rotatoria. Some remarks on their organization will be found in Part I. (p. 482) of this work; and here I shall introduce further particulars, chiefly derived from the first edition of this work (1834), p. 182, and from Dujardin's *Hist. des Infusoires,* p. 661. They have oblong bodies, contracted into a ball; furnished with four pairs of short feet or mammilliform processes, each terminated by simple or double hooked claws; mouth very narrow, siphon-shaped; with an internal maxillary apparatus composed of two lateral moveable pieces, and of a strong muscular œsophageal bulb, furnished with horn-like dental articulated processes.

The Tardigrada stand on the one side between the Rotatoria (Systolides, *Duj.*) and the Helminthidæ, and on the other between the Annelida and Arachnida.

These creatures are usually found attached to aquatic plants which float upon still water. I first obtained them from ponds in the Regent's Park. By placing some water with the plants in a common white hand-basin, and shaking the vegetation, they are detached and fall to the bottom of the basin, from whence they are readily taken. They are generally met with, in company with the larger kinds of Rotatoria, in moss. They are very sluggish in their movements, and are commonly known under the name of "little water-bears." Under the polarizing microscope the manducatory apparatus exhibits the same appearance as horn. They are capable of resuscitation after being dried. They vary in length from 1-20″ to 1-50″.

M. Doyère, in an elaborate Memoir in the 'Annales des Sciences,' has divided the Tardigrada into four genera:—

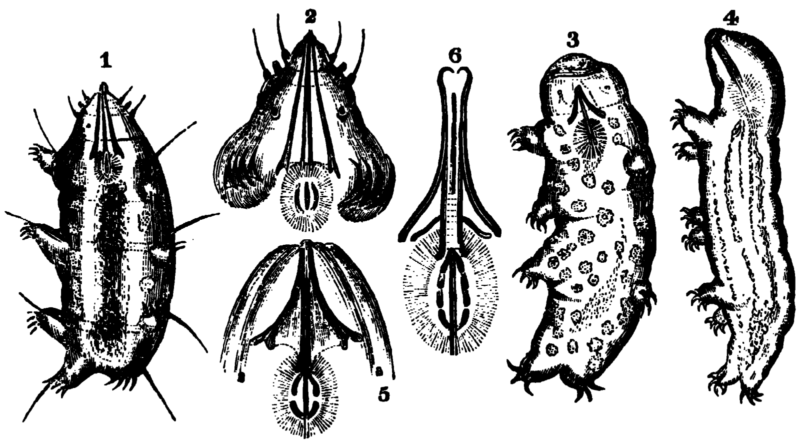
Genus EMYDIUM.—Body oval, anterior part narrow, and terminating in a pointed mouth, near to which, on each side, are flesh-like papillæ. Feet armed with four distinct claws; colour reddish. Found among moss (*Bryum*). (Figs. 1, 2.)

Genus MACROBIOTUS.—Body more cylindrical; obtuse anteriorly; no setæ; each foot furnished with two claws. Found with the preceding; also in rivulets. (See fig. 6.)

Genus TARDIGRADA.—Body stout, oblong; mouth not so sharply pointed. Found in stagnant water, on aquatic plants, and on the *Hypnum fluitans*. (See figs. 3, 4, 5.)

Genus MILNESIUM.—Characters unknown.

For further particulars consult the General History, at p. 482 of this work.



TARDIGRADA, OR LITTLE WATER-BEARS.

Fig. 1. *Emydium*, magnified 130 diameters. Fig. 2. Head of the same, magnified 300 times. Figs. 3, 4. *Tardigrada*, magnified 160 times. Fig. 5. Head of same, magnified 300 times. Fig. 6. Mouth apparatus of *Macrobiotus*, greatly magnified.

OF THE GROUP BACILLARIA.

Sub-group DESMIDIEÆ or DESMIDIACEÆ.

(Page 1, Plates I., II., III., XVI.)

[Class Algæ, Order *Chlorospermeæ*, Family *Desmidiaceæ* of Botanists.]

Cells of two symmetrical valves, devoid of silex, mostly figured, their junction marked by a pale interruption of the endochrome, frequently also by a constriction; increasing by the formation of two new half-cells, which become interposed between the older, so that the two newly-produced cells consist each of a new and an old half-cell; the transverse division complete or incomplete, the cells thus either free or forming a filament; endochrome green, occasionally converted into ciliated zoospores (in the single known instance, escaping by an aperture at the apex of one or more specially formed lateral tubes); reproduction by conjugation of the contents of two distinct cells, and the formation of sporangia, the contents of which, in after-development, become segmented into a definite number of individualized portions, the last generation of which are set free by the bursting or solution of the containing membrane, and become the first fronds of a new vegetative cycle.

We believe the foregoing diagnosis will apply to and include all the species which we look upon as undoubtedly belonging to this family, and which are introduced into this work. The claims of the genera Cylindrocystis and Mesotænium, as true members of the Desmidiaceæ, not appearing, so far as we can judge, to be satisfactorily established, they are omitted.

The wonderful variety of form and beautiful symmetrical diversity of outline of the members of this family have been dilated on at length in the General History. It seems to us, with regard to the mode of cell-division in the true species of this family, that, normally, the preliminary step in the process is the separation of the cell-contents and the formation of a septum at the central suture, the two halves of the contents becoming thus individualized, whereupon ensues the growth and extension of the primordial utricle and contents, concurrently with the production of the intermediate cell-wall ultimately to form the two new segments, and either complete separation taking place, or the cells remaining united in more or less brittle filaments.

Many of the species, probably all, seem to be liable to an abnormal mode of growth, resulting from the incomplete carrying out of this process, when the new growth forms an intermediate, frequently misshapen structure, producing with the original segments but one uninterrupted cavity,—this irregularity seeming to be primarily due to the omission of the formation of the septum on the recommencement of the vegetative growth (III. 61, 62): *vide* Mrs. H. Thomas, *J. M. Sci.* vol. iii. pl. 5. figs. 17 & 18; also M. de Brébisson, *Liste*, &c. pl. 1. fig. 15; and Mr. W. Archer, *Proc. Nat. Hist. Soc. Dub.* 1859, vol. ii. pl. 1. figs. 9–15.) An inspection of several of the latter figures will, however, show that the intervening structure, in the first instance (from the foregoing cause, as we imagine) rendered abnormal, is not always absolutely shapeless or irregular in its form, but sometimes, its axis of growth striking off at right angles to that of the older segments, assumes the form and often the size of an entire frond. Sometimes, indeed, not only is the axis of growth at right angles to that of the original segments, but its plane of expansion is at right angles to their plane. In each of these latter cases the entire abnormal specimen, therefore, forms a cross,—the interior here, of course, as well as in those cases where the intervening growth does not assume any definite outline, making but one uninterrupted cavity (III. 61). The omission of the formation of a septum, however, can only be looked on as the primary cause of the aberration, the curious change in the direction of the new growth not necessarily following, as the figures, pl. 1. f. 9–11 (*loc. cit.*) seem to prove (III. 62).

The assertion that zoospores occur in this family is based upon the observations made by Mr. W. Archer on *Docidium Ehrenbergii* (Ralfs), and recorded and figured in *Proceedings Nat. Hist. Soc. Dublin*, February 1860; also *Nat. Hist. Review*, July 1860. These observations, though unfortunately and unavoidably not so full in their details as the interest of the case would lead us to wish for, seem to warrant the assumption that the species of this family may be occasionally propagated by zoospores, predicating of the family that which seems to hold in the species in question (*Docidium Ehrenbergii*). Pediastreæ are of course not taken into account. Briefly, the phenomenon alluded to is as follows (III. 46, 47):—From beneath the base of one of the segments, either one, two, or three (the latter rarely) lateral tubercle-like projections are formed, originating not from any portion of the segment itself, but from an extension thereto produced between the inflated base and the sutural line. When more than one is formed, they are usually opposite, but sometimes side by side. A gradual elongation of the projection (or projections) then takes place, the endochrome in the immediate neighbourhood becoming finely granular, and filling what has now become an elongate lateral tube (or tubes) like the finger to a glove, the remainder of the endochrome being as yet not much altered, and the terminal clear space with the active granules being still *in situ*. The endochrome within the lateral tube and in its immediate neighbourhood now becomes segmented into a number of definitely bounded individualized portions, which presently one by one emerge through the opened apex of the lateral tube, and become associated together in an external cluster. The remaining endochrome now becomes drawn into bands, turns brown, and speedily dies. The cluster of gonidia at the apex of the lateral tube now appear to have become encysted each within its own special coat; and the green contents can be seen twisting backwards and forwards within the confining membrane. After a time the contents emerge each from its cyst, by rupturing it, and slowly swim away as pyriform or ovate ciliated bodies,—as we apprehend, veritable zoospores. The author was entirely unacquainted with their after-history; but they resemble so much, in their appearance, growth, and mode of escape from the parent-cell, the similar bodies in Cladophora, &c., which are indubitable zoospores, that we imagine there can be little question as to the nature and function of the bodies occurring in Docidium. It will be noticed that this phenomenon is altogether distinct from, and we believe in no way to be confounded with, that of the active molecular movement of the ultimate granular particles of the endochrome alluded to at pages 10 and 19 of the General History,—a circumstance which, indeed, sometimes accompanied the special one here described, in Mr. Archer's specimens, but sometimes did not, and which is one of very general occurrence under other circumstances and in other cases, and has probably given rise to the assumption, often made in our English books, that zoospores occur in the Desmidiaceæ. Nor is the production of zoospores here briefly described to be in any way confounded with the development of the parasitic plant *Pythium entophytum* (Pringsheim), nor of any species of Chytridium (Braun). The former, indeed, is sometimes met with in various Desmidians, such as *Closterium Lunula*, &c., as well as other Algæ. For a figure of this curious parasitic growth attacking *Eremosphæra viridis* (de Bary) (=*Chlorosphæra Oliveri*, Henfrey, the former name having, we are inclined to think, the priority), *vide* 'Micrographic Dictionary,' 2nd ed. pl. xlv. fig. 8. There can be little or no doubt that some such parasite as that alluded to attacking a species of Closterium has given rise to Ehrenberg's genus Polysolenia, admitted indeed into the Desmidiaceæ by Kützing, but which we here cannot but exclude.

The act of conjugation and formation of sporangia is not uncommonly to be met with in several species. The after-development of the sporangium seems to have been but very rarely witnessed; and the statement made in the diagnosis is founded on the account given by M. Hofmeister (*l. c.*), an extract from which is given at page 17; also on the very similar account given by M. de Bary, 'Untersuchungen über die Familie der Conjugaten:' *vide* pl. 6, showing the development of the sporangium of *Cosmarium Botrytis* (III. 48–54), and of *C. Meneghinii* (III. 55–60), the number of sister-cells formed within the sporangium being fewer than in the instances cited by M. Hofmeister. But although, in the cases cited by M. de Bary, the cells resulting from the segmentation and individualization of the contents of the sporangium are eventually of a Cosmarium-shape, it is, however, not until the young fronds commence self-division in the ordinary way, that the first-formed young segments wholly assume the special characteristics of the species (III. 52, 53, 54 & 58, 59, 60).

The nearest affinities of this family seem undoubtedly to be, on the one hand with the Diatomaceæ (with which family, indeed, they were long associated), and on the other with the Zygnemaceæ (Conjugatæ); while to the Palmellaceæ they also approach through the genus Penium, connected with Cylindrocystis and Mesotænium = Palmoglœa (*Kg.*).

It will be at once seen that the following arrangement of the species is for the most part based on that laid down in Ralfs's 'British Desmidieæ,' 1848, in addition to which the following works have been consulted:—Kützing's 'Species Algarum,' 1849; Nägeli's 'Einzelliger Algen,' 1849; Bailey's (Smithsonian Contributions to Knowledge) 'Microscopical Observations made in South Carolina, &c.', 1850; Brébisson's 'Liste des Desmidiées observées en Basse Normandie,' 1856; de Bary (*op. cit.*), 1858; Papers in 'Nat. Hist. Review,' by Rev. R. V. Dixon and by Mr. Archer, 1858–60. The first and second of a series of papers by Dr. G. C. Wallich, F.L.S., descriptive of some beautiful and interesting species of Desmidiaceæ collected by him in Bengal, had just made their appearance ('Annals Nat. Hist.' March and April, 1860) when we were obliged to go to press. It has seemed to us more advisable to omit any description of those species than to introduce a few only without having it in our power to do so with the whole. In indicating the sources whence we have been able to derive information as to foreign species, it is our pleasing duty to acknowledge the generous and courteous assistance of M. de Brébisson in affording by letter the requisite information which that distinguished and experienced observer has so largely at his disposal, and without which our own acquaintance with the Continental forms not known in this country would have been far more circumscribed.

The following genera included in this family by Kützing in 'Species Algarum' are here excluded, as we conceive either that they are not truly Desmidian, or the unnecessary splitting up of older genera:—

Trochiscia, excluded; Tetraedron, excluded; Pithiscus = *Cosmarium pyramidatum* (Bréb.); Stauroceras = Closterium, in part; Polysolenia (*E.*) = a

Closterium attacked by a parasitic growth (?); Microtheca, excluded; Polyedrium, excluded; Zygoxanthium = Xanthidium, in part; Phycastrum, Asteroxanthium, Stephanoxanthium, = Staurastrum; Grammatonema, a diatom; Bambusina = *Didymoprium Borreri*; Isthmosira = Sphærozosma; Eucampia, a diatom; Geminella, excluded; Raphidium = Ankistrodesmus; Oocardium, excluded.

The other genera included by Kützing are placed here as a distinct group, Pediastreæ.

Didymocladon (*Ralfs*) seems not distinguished from certain Staurastra by characteristics sufficient to separate it from them; we have therefore united them, in which we follow Brébisson.

As to the new or altered genera proposed by Nägeli and de Bary, founded rather on the mode of disposition of the endochrome than on the external form, although we do not venture to deny its probably great importance, yet it seems to us that the characters relied on are in many instances not sufficiently constant for the purpose, as well as that several of the known Desmidian species could not be satisfactorily or indubitably referred to the particular genus to which, judging from analogy, they ought to belong; neither, indeed, does it seem, so far as we can judge, that those writers are themselves satisfied as to the proper place of certain species, nor does the system, as yet, appear quite without the disadvantage of disassociating kindred *forms*. We believe we are fortified in the opinion we here endeavour to express by that of M. de Brébisson. The genera Cylindrocystis and Mesotænium are here omitted from this family, as their claims to admission scarcely seem as yet indubitable; moreover, there seems to us little certainty as to the limitation of the species hitherto described by Kützing and others.

If we have omitted some of the species described by the various authors before cited, it is from a conviction that, when either not satisfied as to their absolute distinctness, or unfurnished with what we could look upon as sufficiently exact details, it was the safest course we could pursue,—as it seemed to us better to leave out a few species, than to insert them with a description which, owing most likely to our own want of perception, might prove insufficient or inaccurate. On the other hand, some may think we have admitted too many species, and that certain of the forms hereafter described may be but "varieties" of whichever may be assumed as the typical specific form; but in this conclusion we cannot coincide, as we are disposed to believe that the species hereafter described (with possibly, indeed, a few rare exceptions) are quite distinct, and, at least so far as British or Irish species are concerned, are always perfectly distinguishable.

An ingenious method of succinctly expressing by means of symbols the external characteristic forms of the genera Tetrachastrum, Micrasterias, and Euastrum, was propounded in a paper by Rev. R. V. Dixon, read to Nat. Hist. Soc. Dub., 3rd June, 1859. We append his own explanation, as the best that could be given:—

"The typical mode of division [in the genera above named] (as exemplified in *Euastrum pinnatum*, *E. oblongum*, &c.) appears to be into three portions or *subdivisions*,—the first, next the line of separation of the segments, extending across the frond, and embracing the two basal lobes; the second including the median lobes; and the third, the extreme or end lobe. This last, or third subdivision, is the most constant. The two former are frequently represented by a mere sinuosity or shallow indentation where the third is distinctly developed; but we never find the first subdivision distinct, and the second and third imperfectly separated. The whole three, indeed, may be merely marked by slight sinuosities, as in *Euastrum cuneatum*; but if any one is separated, it is the third. And this, I may observe, is the order of development of the subdivisions in the growing segment of the typical Micrasterias: the new segment is first hemispherical; the third subdivision is then developed; and afterwards the first and second are separated.

"For the purposes of description these three subdivisions might be denoted by the letters *a, b, c,* and their partial or complete development marked as follows:—When the subdivisions are distinctly separated, their symbols might be separated by commas, thus, *a, b, c*; when any two or more are merely marked by a sinuosity, they may be represented thus, $a\frown b$; and if there is no trace of separation, thus, *ab*; and if, at the same time, the direction of the lines separating the subdivisions were noted, the full description as regards the divisions of the segments would be given. Thus— [See page 721.]

CONSPECTUS OF THE GENERA.

Cells united into an elongated jointed filament (sporangia orbicular, smooth).

- Joints many times longer than broad; neither constricted nor with lateral teeth or projections.
  - Filament not attached ....
    - Endochrome arranged in spiral bands ...... GENICULARIA.
    - Endochrome a simple central longitudinal contracted band ... GONATOZYGON.
  - Filament attached..
    - Endochrome a single longitudinal flattened band .... LEPTOCYSTINEMA.
- Joints mostly broader than long, seldom slightly longer than broad; more or less constricted, or with lateral teeth or angles, or otherwise figured......
  - Filament cylindrical or subcylindrical ....
    - Joints constricted or with a projecting annular rim at one or both ends .... HYALOTHECA.
    - Joints with a bidentate process or angle at opposite sides ...... DIDYMOPRIUM.
  - Filament 3–4-angular or compressed.
    - Joints not constricted ...
      - Filament 3–4-angular; joints having the external margin plane or slightly crenated, united to each other by projections springing from the outer portion of each extremity, thus producing intervening central foramina ... APTOGONUM.
    - Joints more or less deeply constricted.
      - Filament 3–4-angular or compressed; joints either closely united by a thickened border for their entire end-margin, or by projections producing intervening central foramina, as in last .... DESMIDIUM.
      - Filament compressed; joints united to each other by minute tubercles or gland-like processes ...... SPHÆROZOSMA.
      - Filament compressed or 3-angular; joints without intermediate tubercles or processes .... SPONDYLOSIUM.

Cells free (owing to complete transverse division).

- Frond often as broad as long, rarely, if ever, as much as three times longer than broad. Sporangia mostly orbicular and spinous, rarely orbicular or quadrate and naked ......
  - Fronds deeply constricted; segments more or less deeply lobed, or if merely undulate or tapering, the ends acutely notched..
    - Segments 3-lobed, lateral lobes attenuated, their apices entire or bifid... **TETRACHASTRUM.**
    - Segments 3–5-lobed, lateral lobes expanded, incised, their external margins dentate or rarely sinuate .... **MICRASTERIAS.**
    - Segments 3–5-lobed, or sometimes only laterally emarginate or sinuate, undulate or tapering; lateral lobes rounded, entire, or sinuately emarginate; end-lobe mostly centrally emarginate or concave, the segments with variously disposed inflated circular prominences (the two latter characters never simultaneously absent*) ... **EUASTRUM.**
  - Fronds distinctly, mostly deeply, constricted; segments mostly entire, or if somewhat undulate, the ends not notched ....
    - Segments not lobed, entire, mostly rounded, rarely undulate at the margin, ends never emarginate, sometimes with a solitary central inflated prominence on each front surface; without spines or processes .... **COSMARIUM.**
    - Segments compressed, entire, spinous, with a central circular, cylindrical, or conical projection on both front surfaces .... **XANTHIDIUM.**
    - Segments compressed, entire, either with two or with four acute teeth or simple or geminate subulate spines placed on the external angles or prominences, without a central projection .... **ARTHRODESMUS.**
    - Segments in e. v. angular or radiate .... **STAURASTRUM.**
- Frond mostly many times, rarely less than three times, longer than broad. Sporangia smooth (*Penium annulatum* and *Spirotænia muscicola* are sometimes not more than twice as long as broad)...
  - Frond distinctly constricted at the middle.
    - Segments inflated at the base ....
      - Ends trilobed. **TRIPLOCERAS.**
      - Ends truncate. **DOCIDIUM.**
    - Segments not inflated at the base ... Ends notched. **TETMEMORUS.**
  - Frond either not at all constricted, or with a slight and gradual attenuation towards the middle...........
    - Frond curved or arcuate, not constricted .... **CLOSTERIUM.**
    - Frond straight, ends truncate or rounded, scarcely or not at all constricted .... **PENIUM.**
    - Frond straight or nearly so, endochrome spirally twisted .... **SPIROTÆNIA.**

* *Euastrum crenatum* (Kg.) is perhaps an exception.

[*Provisionally included.*]

Cells elongate, attenuated, entire, aggregated into faggot-like bundles... ANKISTRODESMUS.

Cells rounded, compressed, deeply constricted, stipitate .... COSMOCLADIUM.

"*Euastrum cuneatum* would be represented by $a \frown b \frown c$.
Euastrum pinnatum, " " a, b, c, parallel.
Euastrum oblongum, " " a, b, c, subradial.
Micrasterias denticulata, " " a, b, c, radial.
Euastrum pectinatum, " " $a \frown b$, c, parallel.
Tetrachastrum " " ab, c, parallel."

The following contractions are employed, which may require explanation:—f. v., front view; s. v., side view; e. v., end view; tr. v., transverse view; e. f., empty frond; L., length, B., breadth, of frond. The measurements are expressed in so many fractions of inch by the use of two acute marks, thus, L. 1-598″ = length of frond $\frac{1}{598}$th of an inch. In most of the foreign species we are without the data to give measurements. G.B., Great Britain; I., Ireland; F., France; G., Germany; U.S.A., United States of America, referring to the record of the occurrence of the species in those countries. It is believed that even this rough attempt at an indication of the distribution of these organisms may not be altogether without its use. Doubtless many occur, and perhaps different forms, in other countries of Europe; and information is much wanted in this respect as to other parts of the world.

Where a species occurs under another name in the works above cited, we have, as far as possible, given the synonym, but should it occur there under the same name, it is not repeated.

The characters printed in italics are such as immediately distinguish each species from its nearest allies, and, the genus being known, are probably those which should be first consulted; but it is always requisite to peruse the whole of the characters applicable to each species and genus, with a view to render the identification accurate.

A. *Plant an elongated jointed filament. Sporangia orbicular, smooth.*

1. Joints many times longer than broad.

Genus GENICULARIA (De Bary).—Filament cylindrical; joints elongate, cylindrical, without a constriction or inflation, ends truncate; *endochrome arranged in two or three spiral bands* upon the cell-wall, sometimes irregular. Joints previous to conjugation disunited, and bent during the process; sporangium placed between the empty conjugated joints.

GENICULARIA *spirotænia* (De Bary).—Joints ten or twenty times as long as broad, very slightly enlarged towards their ends, on the outer surface rough with minute scattered granules. Sporangium orbicular, smooth, placed between the conjugating joints, which are bent into a knee-shape, with which it remains for some time in connexion. "B. 1-130‴-1-100.‴" (III. 3.) G.

Genus GONATOZYGON (De Bary).—Filament cylindrical; joints elongate, slender, cylindrical or narrow-fusiform, without a constriction or inflation, ends truncate; endochrome *a single, central, longitudinal, undulatory, contracted band.* Joints previous to conjugation disunited, and during the process bent into a knee shape; sporangium as last.

GONATOZYGON *Ralfsii* (De Bary).—Joints *cylindrical* with the ends somewhat dilated, ten to twenty times as long as broad, rough on the surface with numerous minute scattered granules; endochrome sometimes bifid at the extremities, usually with a pale space at the centre, and with a longitudinal median series of lighter-coloured dense corpuscles. Sporangium same as preceding species. (III. 1, 2.) L. 1-100″; B. 1-2350″. *Docidium asperum* (Ralfs); *Leptocystinema asperum* (Archer). G.B., I., F., G.

G. *Brebissonii* (De B.).—Joints *narrow-fusiform*, subcapitate at ends, loosely united, often single, rough on the surface with minute scattered granules; endochrome usually with a pale space at the centre, and a median series of corpuscles. Sporangium as preceding. *Docidium asperum* (Bréb.); *Lep. Portii* (Archer). L. 1-200″ to 1-105″; B. 1-3500″. I., F., G. β much smaller, and joints varying in length.

Genus LEPTOCYSTINEMA (Archer).—Filament *attached*, cylindrical; joints elongate, cylindrical, slender, linear, without a constriction or inflation, ends truncate; endochrome *a longitudinal flattened band*. (No evident gelatinous sheath.)

A genus under the above name was founded by Mr. W. Archer (Nat. Hist. Rev. vol. v. p. 250) for the reception of the single species now here included, as well as the two species of Gonatozygon (De B.), not being, however, then aware that De Bary had previously established the latter genus in 'Hedwigia.' However, as the reproductive condition of *Lep. Kinahani* (Archer) is yet unknown, we deem it more advisable to allow that species to remain under its original name, and, for the present at least, to retain the genus, distinguishing it here from Gonatozygon by the filaments being attached (a singular circumstance in Desmidiaceæ), and the endochrome a flattened band. The species is very distinct indeed from the two preceding.

LEPTOCYSTINEMA *Kinahani* (Archer).—Filament 2 to 3 inches long, often breaking up into separate joints; joints 20 to 40 times as long as broad, linear, smooth; endochrome in its broader diameter filling the entire width of the joint—in the narrower, not more than one-third, occupying the centre of the joint, and at the central pale space curved towards the cell-wall, and having imbedded within it a longitudinal median series of globular, light-coloured, dense corpuscles (one occupying the centre of the pale space), retracted at each end of the joint, leaving a clear space in which are active granules. Sporangium unknown. L. 1-200″ to 1-50″; B. 1-1900″. (III. 4.) I.

2. Joints mostly broader than long, very seldom slightly longer than broad.

Genus HYALOTHECA (Ehr.).—Filament *cylindrical*, very gelatinous; joints having either *a slight constriction*, which produces a crenate appearance, or *a grooved rim at one or both ends*, which forms a bifid projection at each side; end view circular; endochrome radiate.

HYALOTHECA *dissiliens* (Bréb.).—Filament fragile, crenate; joints usually broader than long, *with a shallow groove round each*, dividing the endochrome into two portions. Sporangium globular, smooth, placed within the persistent connecting tube formed by the mutual fusion of a fresh extension from, and produced between, the sides opposed to each other of the conjugating pairs of joints, the filament having previously broken up into single joints. (II. 32 & 35). L. 1-2105″ to 1-1351″; B. 1-1308″ to 1-833″. = *Conferva dissiliens* (Smith), *Glœoprium dissiliens* (Berk., Hass.), *Hyalotheca mucosa* (Kg.). G.B., I., F., G., U.S.A.

H. *mucosa* (Ehr.).—Filament scarcely fragile, mucous sheath very broad; joints about as broad as long, *not constricted, but having at one of the ends a minute bidentate projection* on each margin, the adjoining end of the next joint being similar, these projections being produced by an annular grooved rim. L. 1-1250″ to 1-660″; B. 1-1250″ to 1-1111″. = *Conferva mucosa* (Mert., Hook., Harv.), *Glœoprium mucosum* (Hass.), *H. Ralfsii* (Kg.). G.B., I., F.

H.? *dubia* (Kg.).—Filament without a mucous sheath (?); joints rather broader than long, with *two puncta near each margin*. G.

Genus DIDYMOPRIUM (Kg.).—Filament gelatinous, *cylindrical, regularly twisted*; joints with *a bidentate process or angle at each side*; end view circular, or broadly elliptic, with two opposite projections formed by the angles; endochrome radiate.

DIDYMOPRIUM *Grevillii* (Kg.).—Sheath distinct; joints broader than long, *with a thickened border at their junction; angles bidentate; teeth angular; transverse view broadly elliptic.* Sporangium orbicular, formed within one of the two conjugating joints, the endochrome passing over from one by a narrow connecting tube produced between the otherwise but little altered broken-up single joints. L. 1-464″; B. 1-470″. = *Desmidium cylindricum* (auct.), *Arthrodesmus? cyl.* (Ehr.), *Desmidium compressum* (Corda), *D. Grevillii* (De B.). G.B., I., F., G., Prussia, U.S.A.

D. *Borreri* (Ralfs). — Joints inflated, *barrel-shaped,* longer than broad, *without a thickened border at their junction; angles bicrenate, crenatures rounded; transverse view circular.* Sporangium elliptic, formed within the (for some time) persistent extensions from the conjugating joints, which do not previously break up into single joints, but couple, still united in the filament, in a confused or zigzag manner, some of the joints remaining unchanged. (II. 38, 39.) L. 1-939″; B. 1-1030″. = *Bambusina Brebissonii* (Kg., Bréb.). G.B., I., F., G., U.S.A.

Genus APTOGONUM (Ralfs).—Filament 3–4-*angular*; joints *not constricted, plane or crenated at the lateral margins,* united only at the outer portions of each of their end margins by mutual projections, thus producing intervening central oval foramina.

APTOGONUM *Baileyi* (Ralfs).—Joints in f. v. quadrangular, about as broad as long, *their lateral margins plane*; foramina broadly oval; in e. v. triangular, angles somewhat rounded. (III. 5, e.v. 6.) U.S.A.

Genus DESMIDIUM (Ag.).— Filament 3–4-*angular or compressed,* regularly twisted; joints *bidentate or bicrenate at the angles or lateral margins,* and either closely united throughout the whole of their end margins by a thickened border, or only at the outer portion of each by mutual projections, and thus producing intervening central oval foramina.

DESMIDIUM *aptogonum* (Bréb.). — Joints in f. v. quadrangular, broader than long, with two rounded crenatures on each lateral margin, united at the outer portion only of each end margin by mutual projections, *thus producing intervening central oval foramina.* G.B., F., G., U.S.A. *a.* Filament triangular, regularly twisted, crenatures rounded. L. 1-1490″; B. 1-1000″. (III. 7, e. v. 8.) *β,* filament compressed, crenatures shallower, and slightly angular. L. 1-1295″; B. 1-925″. = *Aptogonum Desmidium* (Ralfs). G.B., I., F., G., Italy, Sweden, U.S.A.

D. *Swartzii* (Ag.). — Filament *triangular, equal,* with a single longitudinal waved dark line formed by the third angle; joints in front view somewhat quadrangular, broader than long, with *two slightly angular* crenatures on each lateral margin, united at the whole of their end margins by a thickened border; end view triangular; endochrome three-rayed. L. 1-2000″ to 1-1666″; B. 1-633″.

D. *quadrangulatum* (Ralfs).—Filament *quadrangular,* varying in breadth from its twisting, having two longitudinal waved lines; joints in f. v. broader than long, with *two somewhat rounded crenatures* on each lateral margin, united by the whole of their end margins; e. v. quadrangular; endochrome four-rayed. (II. 37, 40.) L. 1-1244″; B. 1-603″ to 1-455″. = *D. quadrangulare* (Kg.). G.B., F., G., U.S.A.

D. *undulatum* (Corda).—Filament *triangular*; joints in f. v. with a slight central notch at each side, and *four broad crenatures* at each lateral margin, united by the whole of their end margins.

D. *didymum* (Corda).—Filament triangular; joints in f. v. bidentate, broader than long, united by the whole of their end margins; e. v. triangular; *angles acutely bifid.* = *Desmidium bifidum* (Menegh.). G., Italy.

Genus SPHÆROZOSMA (Corda).—Filament *compressed*; joints *deeply divided* on each side, thus forming two segments, and giving a pinnatifid appearance to the filament, *united to each other by minute tubercles or gland-like processes.*

SPHÆROZOSMA *vertebratum* (Ralfs).—Joints as long as broad, constriction deep, acute; segments reniform, gland-like processes *oblique, solitary at the centre of each margin.* A gelatinous sheath evident. Sporangium spherical, smooth, placed between the empty segments, the filament previously to conjugation breaking up into single joints. L. 1-1429"; B. 1-909" to 1-666". (I. 15-17.) = *Sph. elegans* (Corda, Hass.), *Odontella unidentata* (Ehr.), *Isthmia vertebrata* (Menegh.), *Isthmosira vert.* (Kg.). G.B., I., F., G., Italy, U.S.A.

S. *excavatum* (Ralfs). — Joints longer than broad, subquadrate, very minute; constriction a deep rounded sinus on both sides, and *two sessile gland-like processes on each margin* at their junction; angles sometimes with three very minute teeth; no evident gelatinous sheath. Sporangium elliptic, placed between the empty joints, the filament previously breaking up. L. 1-2575"; B. 1-3050". = *Isthmosira excavata* (Kg.). G.B., I., F., U.S.A.

S. *filiforme* (Ehr.).—Joints about as long as broad; constriction acute; segments elliptic, and united by *double slender processes which include a quadrate foramen between each pair.* = *Isthmosira filiformis* (Kg.). G.

S. *lamelliferum* (Corda).—Joints about one-third broader than long, constriction deep, slightly rounded within; segments *incurved*, reniform; connecting processes "flattened," colourless; a gelatinous sheath. G.

Genus SPONDYLOSIUM (Bréb.)—Filament *compressed or 3-angular*; joints *deeply divided on each side*, thus forming two segments, and giving a pinnatifid appearance to the filament, and *without intermediate tubercles or processes.*

SPONDYLOSIUM *stomatomorphum* (Br.). — Joints about one-third broader than long, constriction deep, segments *reniform, ends broadly rounded*; no sheath. = *Isthmia stomatomorpha* (Menegh.). F.

S. *pulchrum* (Bail. sp.).—Joints twice as broad as long, constriction not deep, acute, segments *elliptic*; junction margins straight, *forming short connecting bands*; gelatinous sheath wide. = *Sphærozosma pulchrum* (Bail.). U.S.A.

S. *pulchellum* (Archer). — Filament minute, fragile; joints about as broad as long, sharply incised; *segments laterally inflated at the base*, thus giving a pouting appearance to the joint, *narrowing to the ends*, which are *straight*, with square angles; endochrome containing in each segment a single, central, lighter-coloured, globular corpuscle. No evident gelatinous sheath. L. 1-2330"; B. 1-2330". (III. 10.) I.

S. *depressum* (Bréb.). — Joints somewhat broader than long, *subquadrate, constriction a rounded sinus*, angles rounded, ends straight, furnished at end margin on upper surface with three rounded protuberances; "no sheath." (III. 9.) F.

S. *serratum* (Bailey, sp.). — Joints broader than long, constriction a triangular notch; segments forming *lateral triangular acute projections*, thus giving a serrated outline to the filament; junction margins straight. = *Sphærozosma serratum* (Bail.). U.S.A.

S. *secedens* (De Bary, sp.).—Filament very fragile, joints as long as broad, constriction a shallow rounded sinus; segments subelliptic, *ends concave*; no gelatinous sheath. L. 1-287'". = *Sphærozosma secedens* (De Bary). G.

B. *Fronds simple, free, owing to complete transverse division.*

1. Fronds distinctly constricted at the middle, never as much as three times longer than broad. Sporangia mostly spherical and spinous or tuberculated, or very rarely spherical or quadrate and naked.

Genus TETRACHASTRUM (Dixon). — Frond compressed, deeply constricted into two 3-lobed segments; lateral lobes projecting horizontally, or sometimes divergent, *broadest at their base and simply attenuated outwards*; end lobe laterally expanded into a *horizontal attenuated projection* on each side, subtending the lateral lobes; central constriction a gradually widening incision (*ab, c*, vide suprà).

* *Extremities of lobes entire, mucronate or acute.*

TETRACHASTRUM *arcuatum* (Bailey, sp.).—Frond rather broader than long, pinnatifid, quadrangular; lateral lobes long, slender, *arcuate*, tapering, *divergent* from those of the opposite segment, their extremities acute; terminal lobe narrow, produced, its lateral projections *abruptly transverse, slender*, attenuated, acute; ends slightly concave at the centre. = *Micrasterias arcuata* (Bail.). U.S.A.

T. *expansum* (Bailey, sp.). — Frond about as broad as long, somewhat stellate; lateral lobes long, slender, *straight*, conical, divergent from those of the opposite segment, their extremities acute; terminal lobe narrow, produced, its lateral projections *somewhat divergent, short*, quickly tapering, acute; ends concave. = *Micr. expansa* (Bail.). U.S.A.

T. *mucronatum* (Dixon). — Frond longer than broad, subelliptic; lateral lobes *very broad*, straight on the margin forming the base of the segment, turgid on the upper margin, their extremities rounded, furnished on the margin with *one, two, or three minute mucro-like spines*, one always at the extremity or basal angle of the segment, others, when present, irregularly placed on the upper margin; terminal lobe short, very broad, its lateral projections short, stout, quickly tapering, somewhat incurved at extremities, which are mucronate; ends rounded, with a very shallow inconspicuous central concavity; tr. v. broadly elliptic; e. f. punctate. L. 1-167″; B. 1-235″. I.

2* *Extremities of the lobes bidentate.*

T. *oscitans* (Dixon).—Frond about as broad as long, pinnatifid; lateral lobes separated from the terminal by a rounded sinus, *horizontal, conical*, their extremities bidentate; end lobe short, broad, its lateral projections *short, conical*, usually bidentate, narrower and shorter than the lateral lobes; ends convex at the centre; tr. v. fusiform, e. f. punctate. L. 1-256″; B. 1-211″. (II. 28, 29). = *Euastrum holocystis* (Kg.); *Holocystis oscitans* (Hass.); *Micrasterias oscitans* (Ralfs). G.B., I., F., U.S.A.

T. *Americanum* (nobis). — Frond broader than long, suborbicular, pinnatifid; lateral lobes separated from the terminal by a deep acute incision, horizontal, conical, *tapering*, their extremities bidentate; end lobe short, its lateral projections *long, tapering*, bidentate at their extremities, *as broad and long as the lateral lobes*; ends broadly rounded. = *Micrasterias incisa* (Kütz.), Bailey, in 'Micr. Obs. in S. Carolina,' &c., but surely not that species; we are therefore obliged to place it here under another specific name.

T. *pinnatifidum* (Dixon).—Frond rather broader than long, *plane*, pinnatifid; lateral lobes separated from the terminal by an *equal subacute incision*, triangular, subconical, horizontal, their extremities bidentate; end lobe short, its lateral projections transverse, *short*, bidentate at the extremities, ends *straight* (colour pale). L. 1-440″; B. 1-392″. = *Micrasterias pinnatifida* (Ralfs, Bréb.); *Euastrum pinnatifidum* (Kg.). G.B., F., G., U.S.A.

T. *didymacanthum* (Näg. sp.).—Frond about as broad as long, pinnatifid; lateral lobes separated from the terminal by a *wide rounded sinus*, their *lower margin convex*, in apposition with those of the opposite segment for a portion of their length, then slightly divergent, their upper margin *nearly straight, horizontal*, their extremities bidentate; end lobe long, united to the basal portion by a narrow neck, its lateral projections short, their extremities bidentate, ends slightly convex. L. 1-40‴; B. 1-40‴. = *Euastrum didymacanthum* (Näg.). G.

T. *quadratum* (Bail. sp.). — Frond broader than long, pinnatifid, quadrangular; lateral lobes separated from the terminal by a wide rounded sinus, *somewhat inflated* at their base, elongate, slightly divergent from those of the opposite segment, their *produced extremities slender*, bidentate; end lobe narrow, produced, its lateral projections transverse, elongate, slender, bidentate at the extremities; ends with a slight central concavity. = *Mic. quadrata* (Bail.). U.S.A.

Genus MICRASTERIAS (Ag.).—Frond mostly lenticular, as long as or slightly longer than broad, deeply constricted into two lobed segments; segments usually semiorbicular, 5- or sometimes 3-lobed; lobes *incised or divided, mostly radiant, narrower at the base and widening upwards, their ultimate subdivisions spreading, dentate or minutely spined*, or rarely only sinuate at the outer margin; central constriction usually linear.

* *The subdivisions of the lobes spreading in a plane at right angles to that of the frond.* (*a, b, c.*)

MICRASTERIAS *muricata* (Ralfs). — Frond quadrangular; segments sub-5-lobed, lobes opposite; basal lobes tripartite, middle lobes bipartite; end lobe exserted and laterally divergent, its lateral extensions bipartite; all the subdivisions of *all* the lobes divergent and *disposed in a plane at right angles to the plane of the frond*, their extremities terminating in three or four projecting points; the intervals between the lobes deep rounded sinuations; ends straight, entire. = *Euastrum muricatum* (Bailey). U.S.A.

2* *The subdivisions of the lobes spreading in the same plane as the frond.*

† Frond subelliptic; segments 3- or sub-5-lobed, lobes spreading, the intervals between the lobes being wide; lateral lobes bipartite, their subdivisions divergent, end lobe exserted and laterally divergent. (*a⁀b, c.*)

M. *Baileyi* (Ralfs).—Frond *granulated all over*; segments 3-lobed; lateral lobes deeply bipartite, subdivisions *slender*, their extremities bidentate, the lower subdivisions horizontal, approximate to those of the opposite segment, the upper divergent; end lobe narrow below, exserted, transversely expanded, its lateral extremities truncate; ends concave. U.S.A.

M. *ringens* (Bailey). — Frond somewhat coarsely *granulated at the margin*; segments 3-lobed; lateral lobes somewhat broadly bipartite, *stout*, divergent from those of the opposite segment, their subdivisions having the extremities obscurely bidentate; end lobe narrow below, exserted, transversely expanded, its lateral extremities obtuse; ends concave. U.S.A.

M. *furcata* (Ag.). — Frond smooth; segments sub-5-lobed; basal and middle lobes bifid, their subdivisions *slender, linear, divergent*, and *forked* at the apex, bifurcation usually *incurved*; end lobe exserted, with a rounded sinus between the considerably produced divergent extensions from the angles, which are ultimately forked, their bifurcations incurved. L. 1-135″; B. 1-156″. = *M. radiata* (Hass.), *M. Melitensis β gracilis* (Kg.). G.B., U.S.A.

M. *Crux-Melitensis* (Ralfs). — Frond smooth; segments sub-5-lobed; basal and middle lobes bifid, subdivisions *short, stout*, and *bidentate* at the apex; end lobe exserted, with a rounded sinus between the produced divergent extensions from the angles, which are ultimately bidentate. L. 1-206″; B. 1-221″. (I. 22). = *Euastrum Crux-Melitensis* (Ehr.); *M. Melitensis* (Menegh.). G.B., F., G., Italy, U.S.A.

2† Frond angular-elliptic, subquadrate or suborbicular; segments 3-lobed; lobes spreading, the intervals between the lobes being usually wide; lateral lobes either bipartite and inciso-dentate or truncate on outer margin; end lobe mostly exserted, divergent. (*a⁀b, c.*)

M. *Americana* (Ralfs).—Frond angular elliptic, more or less punctate; segments 3-lobed; lateral lobes broad, *cuneate*, their margins concave, *inciso-serrate*; end lobe *broad*, cuneate, and exserted, bipartite at the angles, the subdivisions narrow, and minutely dentate at the extremities; end concave. L. 1-204″; B. 1-254″. (II. 44, bad). = *Euastrum Americanum* (Ehr.). G.B., I., F., U.S.A. *β*, margins waved rather than dentate.

M. *foliacea* (Bailey). — Frond subquadrate, smooth; segments 3-lobed; lateral lobes deeply bipartite, inciso-dentate, their margins extending to an equal distance from the middle line of the frond, with a *short rounded tooth-like projection next the end lobe*; end lobe *narrow*, somewhat dilated above, angles emarginate; ends concave. U.S.A.

M. *incisa* (Kg.). — Frond about as broad as long, suborbicular; lateral lobes horizontal, sides parallel, *abruptly truncate, with a tooth at each angle*; end lobe short, very broadly cuneate, entire, its angles acute. = *Euastrum Crux-Melitensis* (Ehr.). G., F., U.S.A.?

M. *decemdentatum* (Näg.). — Frond about as broad as long, suborbicular; segments 3-lobed; lateral lobes horizontal, side subparallel, *obscurely bipartite, their subdivisions acutely bidentate*; end lobe broadly cuneate, entire, angles acute; ends rounded. L. 1-55‴; B. 155‴. = *M. Neodamensis* (Braun); *M. Itzigsohnii* (Bréb.). F., G.

3† Frond circular; segments 5-lobed; lobes approximate, the intervals between the lobes being linear or very deep and acute incisions; basal and middle lobes dichotomously divided or deeply incised; end lobe narrow, seldom and but very slightly exserted. (*a, b, c.*)

M. *Torreyi* (Bail.).—Frond smooth; segments 5-lobed; basal lobes bifid, middle lobes trifid, the subdivisions nearest the opposite segments and those nearest the terminal lobe *bidentate* at the apex; the intermediate three terminating in *acute points*; all somewhat *inflated and tapering*; terminal lobe narrow, not exserted, spreading at the angles into divergent tapering points; ends slightly emarginate. U.S.A.

M. *denticulata* (Bréb.).—Frond orbicular, smooth; segments 5-lobed; basal and middle lobes twice dichotomous; ultimate subdivisions *truncato-emarginate, with rounded angles*; end lobe simply thrice emarginate. Sporangium orbicular, beset with scattered stout elongate spines, at first simple and obtuse, afterwards forked or trifid, their divisions finally again branched and recurved. L. 1-113″, B. 1-138″. (II. 22, sporangium). = *Euastrum Rota* (Ehr.) in part. G.B., I., F., G., Italy, U.S.A. *β*, ends broader, slightly hirsute at the terminal margin (Bailey).

M. *rotata* (Ralfs).—Frond orbicular, smooth; segments 5-lobed; basal lobes twice, middle lobes thrice dichotomous; ultimate subdivisions *acutely bidentate*; end lobe very slightly exserted, its angles very slightly produced, bidentate, ends emarginate. In transverse view is seen an inflated protuberance just over the central isthmus, which may possibly exist in other species of Micrasterias. L. 1-91″, B. 1-104″. (I. 20.) = *Euastrum Rota* (Ehr., Näg.) in part; *Eutomia rotata* (Harvey). G.B., I., F., G., Italy, U.S.A.

M. *fimbriata* (Ralfs).—Frond orbicular, smooth; segments 5-lobed; basal lobes twice, middle lobes generally thrice dichotomous; ultimate subdivisions obtusely emarginate, *each furnished with two curved acute spines*; end lobe somewhat exserted, the angles slightly produced and rounded, and each furnished with two or three minute spines; ends concave. L. 1-108″, B. 1-119″. = *Euastrum Rota* (Ehr.) in part. G. B., U. S. A.

M. *apiculata* (Menegh.).—Frond orbicular, *hispid all over with scattered spines*; segments 5-lobed; basal and middle lobes once or twice incised, their external margin toothed, ultimate subdivisions furnished with two acute spines; end lobe narrow, spinous on external margin. = *Euastrum aculeatum* (Ehr.). G., F.

M. *radiosa* (Ag.).—Frond orbicular, smooth; segments 5-lobed; basal lobes twice, middle lobes generally thrice dichotomous, ultimate subdivisions *inflated, attenuate towards the end*, bidentate; end-lobe emarginate, its angles dentate. (I. 21.) L. 1-138″; B. 1-138″. = *Euastrum Sol* (Ehr.). G. B., I., F., U. S. A.

M. *papillifera* (Bréb.).—Frond orbicular, having the principal sinuses *bordered by a row of minute granules*, otherwise smooth; segments 5-lobed; basal and middle lobes twice dichotomous, their ultimate shallow subdivisions terminated by *two, sometimes three, gland-like teeth*; end-lobe emarginate, its angles dentate. Sporangium as in M. *denticulata*, but considerably smaller. L. 1-221″-1-205″; B. 1-238″-1-211″. (I. 18, spor. 19). G.B., I., F., U.S.A.

4† Frond orbicular; segments 5-lobed; lobes approximate, the intervals between the lobes shallow narrow incisions; the lateral lobes dentate, crenate, or slightly sinuate; end lobe broad, not exserted. (*a⁀b, c.*)

M. *quadragies-cuspidata* (Ralfs).—Frond *hispid all over with scattered minute hair-like spines*; segments 5-lobed; basal and middle lobes slightly bipartite, their subdivisions bidentate; end lobe very broad, cuneate, truncate, its angles bidentate. = *Cosmarium quadragies-cuspidatum* (Corda). G.

M. *truncata* (Bréb.).—Frond orbicular, *smooth*; segments 5-lobed; basal and middle lobes obscurely bipartite, extremities bidentate; end lobe very broadly cuneate, *bidentate at the angles*, and with a slight central concavity. L. 1-240″; B. 1-250″. = *Cosmarium truncatum* (Corda); *Euastrum Rota* (Ehr.) in part; *M. semiradiata* (Kg.); *Euastrum semiradiatum* (Näg.). G.B., I., G., F., U.S.A.

M. *crenata* (Bréb.).—Frond orbicular, *smooth*; segments 5-lobed; basal and middle lobes usually *crenate, or sinuate*; end-lobe very broadly cuneate, rounded at the ends, *entire*. L. 1-244″; B. 1-263″. G. B., I., U. S. A.

5† Frond oblong, elliptic; segments 5-lobed; lobes approximate or spreading, intervals between the lobes linear or somewhat sinuous, all the lobes similar at the extremities, the end lobe the broadest. (*a, b, c.*)

M. *Jenneri* (Ralfs).—Frond oblong, minutely granulated; segments 5-lobed; basal, middle, and end lobes cuneate, obscurely bipartite, and their subdivisions *emarginate, or with merely a slight central concavity*; angles rounded; end-lobe at external margin considerably the broadest. L. 1-147"; B. 1-209". G.B., I. *a* (Ralfs), granules like mere puncta, lobes slightly bipartite, subdivisions emarginate. *β* (Ralfs), granules larger, giving a dentate appearance to the margin, otherwise as *a*. *γ* (Archer), granules giving a rough appearance to the margin, lobes slightly concave, margins rounded, not bipartite, without emarginate subdivisions.

Genus EUASTRUM (Ehr.).—Frond longer than broad, compressed; deeply constricted into two lobed or sinuated segments; segments usually pyramidal, 5- or 3-lobed or merely sinuous, *possessing variously disposed circular inflated protuberances* (very rarely absent); lateral lobes *opposite*, very rarely radiant, rounded or sinuated at the extremities; end lobes acutely *incised or emarginate* at the centre, rarely only concave; central constriction linear. (The inflated protuberances and the emarginate ends rarely (if ever?) simultaneously absent.)

* *Segments deeply lobed; separating sinuses directed inwards and downwards; the end lobe cuneate and partly included within the notch formed by the projection of the lateral lobes.*

EUASTRUM *verrucosum* (Ehr.).—Frond somewhat longer than broad, *rough all over with conic granules*; segments 3-lobed, somewhat divergent, *all* the lobes broad, cuneate, with a very *broad shallow external sinus* (*ab, c*).

Empty frond: f.v. segments with one large circular basal inflation on surface, one smaller on each side, and two others on the end lobe; s. v. segments inflated at the base, narrowed into a short neck, end dilated with a central sinus; e. v. oblong, with three inflations at each side, one at each end, end lobe having 4 divergent lobelets. L. 1-267"; B. 1-270". *Cosmarium verrucosum* (Menegh.), *E. papulosum* (Kg.). G.B., I., G., F., Italy, U.S.A.

E. *oblongum* (Ralfs). — Frond rather more than twice as long as broad, smooth, oblong; segments 5-*lobed*; *lobes nearly equal*, cuneate; lateral lobes, or the basal only, with a broad, shallow, marginal concavity, all their angles rounded, terminal notch linear (*a, b, c*).

Empty frond: f. v. seg. punctate, with three large inflations on surface near the base, two others above and two on terminal lobe; tr. v. three times as long as broad, with three subdistant marginal inflations at each side, and one at each end, in *β* broader in proportion, more elliptic, and inflations close; e. v. end lobe notched at opposite external margins. Sporangium orbicular, beset with numerous conical tubercles. L. 1-156"; B. 1-282". (III. 11.) = *Echinella oblonga* (Grev.); *Euastrum Pecten* (Ehr.); *Cosmarium sinuosum* (Corda); *Eutomia oblonga* (Harv.). G.B., I., F., G., Italy, U.S.A. *β* smaller, narrower, middle lobes rounded, without any marginal concavity.

E. *crassum* (Kg.).—Frond about twice as long as broad, *subquadrilateral*, smooth; segments 3-lobed; basal lobes *very broad*, with a *very broad, shallow marginal sinus*, in which there is sometimes a slight intermediate rounded projection; end lobe cuneate, rounded, terminal notch linear. (*ab, c.*)

Empty frond: f. v. punctate, segments with three inflations below and two above; tr. v. two or three times longer than broad, with three lobes or inflations at each side and one at each end; e. v. end lobe sinuate at opposite external margins. L. 1-193"-1-132"; B. 1-263". = E. *Pelta* (Hass.). G. B., I., F., G., U. S. A. *β* smaller, margins of lateral lobes more concave, sinuations between the lateral and end lobes more closed, the latter more included.

E. *cornutum* (Kg.).—Frond about twice as long as broad: segments 3-lobed, somewhat inflated at base, *outer upper angles of basal portion prolonged into a process-like projection* directed upwards; end lobe included, its notch broad, concave. Empty frond punctate. (*ab, c.*) G.

2 * *Segments sinuously lobed, or tapering; end lobe exserted and united to the basal portion by a distinct neck.*

† End lobe with a linear or acute notch.

E. *pinnatum* (Ralfs). — Frond oblong, about twice as long as broad; segments 5-lobed in a pinnatifid manner, basal lobes slightly emarginate, middle smaller, rounded, entire, end lobe exserted, dilated, its notch linear; *the upper margin of the lobes horizontal.* (*a, b, c.*)

Empty frond: f. v. segments punctate, usually with two large inflations near the base, four smaller between, three others above, and two on end lobe; s. v. central constriction deep, segments inflated at the base, then contracted, again inflated, and again contracted beneath the dilated terminal lobe; tr. v. with four lobes or inflations on each side, and one at each end; e. v. end lobe with a deep sinus at opposite external margins, concave at the sides, so as to produce four divergent lobelets. L. 1-188″; B. 1-454″. G.B.

E. *humerosum* (Ralfs).—Frond about twice as long as broad; segments sub-5-lobed; basal lobes slightly emarginate; middle lobes *narrow, directed upwards, resembling processes*; end lobe with a short neck, partly included between the middle lobes, dilated, its notch linear. (*a, b, c.*)

Empty frond minutely punctate; f. v. segments with three inflations at base, two above and two on end lobe; tr. v. elliptic, with three inflations on each side and one at each end. L. 1-225″; B. 1-382″. G.B., I., F.

E. *affine* (Ralfs).—Frond about twice as long as broad; segments 3-lobed; basal lobes *slightly emarginate*, having intermediate between them and the end lobe *on each side a tubercle* representing middle lobes, *the upper margin of which is horizontal*; end lobe exserted, dilated, its notch linear. (*ab, c.*)

Empty frond: f. v. minutely punctate; the segments with four basal inflations, two above and two on end lobe; tr. v. elliptic, with four inflations on each side and one at each end; e. v. end lobe emarginate at opposite external margins, producing four shallow lobelets. L. 1-230″; B. 1-458″. G.B., I., F., U.S.A.

E. *ampullaceum* (Ralfs).—Frond rather more than one-half longer than broad; segments obscurely 3-lobed, short, *with broad inflated base*; basal lobes *not emarginate*, having on each upper side *a small intermediate tubercle* between each and the end lobe; end-lobe exserted and dilated, its notch linear. (*ab, c.*) Empty frond minutely punctate; f. v. inflations indistinct or confluent; s. v. narrow elliptic, with several inflated protuberances, ends scarcely dilated, rounded; tr. v. with four inflations at sides and one at each end. L. 1-274″; B. 1-394″. G.B., I., F., U.S.A.

E. *insigne* (Hass.).—Frond rather more than twice as long as broad; segments inflated at base, *sides entire, without lateral tubercles*, and *tapering into a long slender neck*; end lobe *dilated*, its notch linear. (*ab, c.*)

Empty frond minutely punctate; f. v. segments with *two inflations at the base*; s. v. narrower, gradually tapering to the end, which is considerably dilated; projections rounded, with a sinus between; tr. v. *subquadrate, slightly concave at sides, with a rounded lobe at the centre of each end*; e. v. end lobe with a sinus at opposite external margins, angles thus protruded into four divergent rounded lobelets. L. 1-232″; B. 1-416″. (III. 12.) G.B., I., U.S.A.

E. *Didelta* (Ralfs).—Frond rather more than twice as long as broad; segments pyramidal, *inflated at the base and again at the middle*, end scarcely dilated, rounded, its notch linear. (*a⌒b, c.*)

Empty frond punctate; f. v. segments with *several inflations* in lines and two at the end; tr. v. *elliptic with four inflations at each side and one at each end;* e. v. end lobe entire at margin. Sporangium orbicular, with subulate spines. (I. 23, 24, tr. v. 25.) L. 1-185″; B. 1-357″. = *Cosmarium Didelta* (Menegh.), *E. binale* (Kg.). G.B., I., F., Italy, U.S.A.

E. *ansatum* (Ehr.).—Frond about twice as long as broad; segments inflated at the base, *tapering upwards without sinuations* into a neck, end *not dilated*, rounded, its notch linear. (*ab, c.*)

Empty frond punctate; f. v. segments turgid on the surface, at the middle *without circular inflations*; tr. v. elliptic, *with a single large inflation at each side*; e. v. end lobe entire at the margin, its divisions circular. L. 1-315″; B. 1-654″. = *E. binale* (Kg.), *Cosmarium ansatum* (Kg.). G.B., I., F., G., Italy, U.S.A.

E. *circulare* (Hass.). — Frond about twice as long as broad, *tapering upwards into a neck*, end not dilated, its notch an acute incision. (*ab, c.*)

Empty frond: segments with *five basal inflations, four in a half circle round the fifth*, and two others at the extremity. = *Cosmarium circulare* (Kg.), *E. circulare*, var. *Hassallii* (Bréb.). G.B., F., U.S.A.

E. *sinuosum* (Lenormand). — Frond about twice as long as broad, segments 3-lobed, basal portion *emarginate at the sides*; end lobe somewhat dilated, its notch linear. (*ab, c.*)

Empty frond punctate; segments with *five basal inflations and two others at extremity*; tr. v. elliptic, with three inflations at each side and one at each end.

L. 1-325″; B. 1-549″. = *E. circulare* β (Rfs.), *E. circulare*, var. *Falasiensis* (Bréb.). G.B., F.

E. *Jenneri* (nobis).—Frond scarcely twice as long as broad; segments 3-lobed, basal portion *subquadrate, emarginate at the sides*; end lobe somewhat dilated, its notch linear. (*ab, c.*)

Empty frond punctate, *segments with several small inflations arranged in alternate lines.* = *E. circulare* γ (Ralfs), *E. circulare*, var. *Ralfsii* (Bréb.). G.B., F.

Mr. Ralfs unites this and the two preceding as three varieties of E. *circulare* (Hass.). They seem, however, to be quite as distinct as any other species described, not only in external outline, but also in the distribution of the superficial inflations.

2 † End lobe straight or concave without a central notch.

E. *pectinatum* (Bréb.).—Frond rather more than twice as long as broad; segments 3-lobed, basal portion *subquadrilateral*; lateral lobes horizontal, deeply emarginate, end lobe much dilated, *straight or slightly concave at ends*, angles entire or emarginate. (*ab, c.*) Empty frond punctate; f. v. segments with three inflations near the base; tr. v. elliptic with three inflations at each side and two at each end; e. v. end lobe with two minute lobelets at each end, and two near them at each side. Sporangium orbicular, beset with conical tubercles. (II. 10 & 30.) L. 1-362″; B. 1-558″. G.B., I., F.

E. *gemmatum* (Kg., Bréb.).—Frond scarcely twice as long as broad; segments 3-lobed, lateral lobes horizontal, deeply emarginate, *the protuberances minutely granulate*; end lobe dilated, *its dilatations inclined upwards, and minutely granulate*; *ends with a deep rounded emargination.* (*ab, c.*) Empty frond slightly punctate; f. v. segments with three granulate inflations near the base; tr. v. broadly elliptic, with three granulate inflations at each side and one at each end; e. v. end lobe cruciform, lobelets rounded, granulate. L. 1-443″; B.. 1-641″. = *Euastrum* (*Eucosmium*) *Hassallianum* (Näg.). G.B., I., F., Prussia.

3 * *Frond without a distinct terminal lobe, frequently having a process or acute angle at corners of terminal portion.*

E. *rostratum* (Ralfs).—Frond scarcely twice as long as broad, oblong; segments with their basal portion deeply emarginate at the sides, connected by a broad neck with the terminal portion; *ends protuberant, angular*, acutely emarginate at the centre, and *having at each side a horizontal subacute projection.* (*ab, c.*) Sporangium orbicular, spinous; spines conical, attenuated. L. 1-650″ to 1-580″; B. 1-1000″ to 1-714″. (I. 26.) G.B., I., F., U.S.A.

E. *pulchellum* (Bréb.).—Frond rather more than one-third longer than broad, oblong; segments with the basal portion *twice or thrice acutely dentate at each inflated basal angle*, and connected by a broad neck with the terminal portion; *ends straight*, acutely emarginate at the centre, angles acutely mucronate; e.f. bearing at the centre of each segment *a single inflated prominence bordered by an annular series of granules* (in s.v. truncate), and a few scattered granules near the projecting parts. (*ab, c.*) F.

E. *elegans* (Bréb., Kg.).—Frond minute, scarcely twice as long as broad, oblong; segments with their basal portion emarginate at the sides, connected by a broad neck with the terminal portion; *ends protuberant, rounded*, acutely emarginate at the centre, *pouting*; s.v. with an inflation at the base of the segments, sides concave, ends rounded. (*ab, c.*) Sporangium orbicular, spinous. = *E. bidentatum* (Näg.). G.B., I., F., G., U.S.A. *a*, neck somewhat constricted, end portion bearing on each side an acute horizontal spine-like projection. L. 1-888″ to 1-445″; B. 1-1441″ to 1-714″. β, segments sinuated, neck not constricted and without spines. L. 1-421″; B. 1-654″. γ, neck not constricted, lateral projections bearing minute spines directed obliquely outwards. = *E. spinosum* (Hass.). L. 1-884″; B. 1-1388″.

E. *crenatum* (Kg.). — Frond very minute, about twice as long as broad, segments pyramidal, *their lateral margin crenate*, ends broad, truncate, *entire.* (*ab, c.*) F., G.

E. *binale* (Ralfs).—Frond very minute, scarcely twice as long as broad, oblong; segments with their basal portion either entire or bicrenate at the sides, slightly contracted beneath the ends; ends dilated, *not protuberant beyond the angles*, its central notch acute, broad; tr.v. with two lateral inflations, ends truncate, angles rounded. (*abc.*) L. 1-1570″ to 1-1428″; B. 1-2400″ to 1-1400″. (III. 13.) = *Heterocarpella binalis* (Turp.), *Cosmarium binale* (Meneghini), *E. Ralfsii* (Kg.), *E. lobulatum* (Bréb.)? *E. dubium* (Näg.). G.B., I., F., U.S.A. β, frond rather larger, rough, with a few scattered granules; margins of segments crenate; acute angles of end portion slightly horizontally prolonged, its notch small, rounded (probably a distinct species).

E. *cuneatum* (Jenner).—Frond large, rather more than twice as long as broad; segments pyramidal, broadest at base and narrowing upwards, *not lobed*, the *sides almost straight*; ends truncate, central notch linear. ($a \frown b \frown c$.) Empty frond without inflated protuberances. L. 1-208″; B. 1-420″. G.B., I.

E. *pelta* (Kg.).—Frond about twice as long as broad, oblong; *segments quadrate*, each lateral margin with *a small rounded protuberance or inflation at the base, another* larger *near the upper end*, and *another* somewhat larger still *at the upper angle*; *ends straight*, not notched. (*ab, c.*) = *Cosmarium Pelta* (Corda). G.

Genus COSMARIUM (Corda).—Frond more or less constricted; segments *undivided*, usually rounded, sometimes slightly sinuated, or rarely slightly contracted, somewhat extended and truncate at the ends, never notched, neither provided with spines nor processes; e.v. elliptic, and sometimes each side with a lateral opposite inflation, or circular.

* *Frond compressed; central constriction a deep, usually linear, incision; e.v. compressed, either elliptic or subcruciform, owing to the projection at each side of a protuberance or inflation.*

† Margins of segments entire, neither crenate nor granulate.

Cosmarium *sublobatum* (Bréb. sp).—Frond scarcely twice as long as broad, oblong; constriction linear, segments *subquadrate*, somewhat wider at the base, *lateral and end margins slightly concave*, smooth, transverse view cruciform. L. 1-523″; B. 1-646″. = *Euastrum? sublobatum* (Bréb.). G.B., I., F., U.S.A.

C. *pusillum* (Bréb. sp.).—Frond very minute, slightly broader than long, constriction acute, segments *angulato-trapezoid*, slightly narrowing upwards, smooth, angles rounded, ends slightly concave. = *Euastrum pusillum* (Bréb.). F.

C. *quadratum* (Ralfs).—Frond about twice as long as broad, constriction deep, linear; *segments quadrate, slightly protuberant on each side at the base*, with rounded angles at the ends, smooth; e.v. compressed. L. 1-510″; B. 1-952″. G.B., F.

C. *Cucumis* (Corda).—Frond about twice as long as broad; constriction deep, linear; segments as broad as long, with the basal angles rounded, *broadly rounded at ends*, smooth; e.v. elliptic. L. 1-362″ to 1-257″; B. 1-568″ to 1-502″. = *Euastrum integerrimum* (Ehr.). G.B., I., F., G., Italy, U.S.A.

C. *Ralfsii* (Bréb.).—Frond large, slightly longer than broad, *orbicular*, constriction deep, linear; *segments semi-orbicular*, rounded at basal angles, smooth; e.v. elliptico-lanceolate; *endochrome radiate*. L. 1-227″; B. 1-270″. = *C. Cucumis* (Hass.). G.B., I., F.

C. *rupestre* (Näg. sp.).—Frond rather more than twice as long as broad, constriction not deep but linear; *segments broadly oval*, turgid, *sides and ends broadly rounded*, smooth; e.f. punctate, puncta scattered. = *Euastrum rupestre* (Näg.). G.

C. *pyramidatum* (Bréb.). — Frond scarcely twice as long as broad, *suboval*; constriction deep, linear; segments pyramidal, *rounded at basal angles, somewhat truncate at the ends*, punctate; e.v. broadly elliptic. Sporangium orbicular, tuberculated. L. 1-471″ to 1-264″; B. 1-759″ to 1-374″. (III. 14, e.v. 15.) = *Pithiscus angulosus* (Kg.). G.B., I., F., U.S.A.

C. *lagenarium* (Corda).—Frond about twice as long as broad, subelliptic; segments *triangular, pyramidal*, punctate; basal angles broadly rounded, sides *somewhat concave*, tapering, ends broadly rounded. = *C. ansatum* (Kg.). G.

C. *tinctum* (Ralfs). — Frond very minute, about as long as broad, constriction producing *an acute notch at each side*; segments *elliptic*, about twice as broad as long, smooth; e.v. narrow elliptic. Empty frond *somewhat reddish. Sporangium quadrate, smooth*, with an empty segment of the conjugated fronds permanently attached to each corner. L. 1-2325″; B. 1-2500″. G.B., I.

C. *bioculatum* (Bréb.).—Frond minute, about as long as broad; constriction deep, producing a *gaping notch at each side*; segments about twice as broad as long, elliptic, smooth; s.v. compressed; e.v. elliptic. *Sporangium orbicular, with conical spines*. L. 1-1416″; B. 1-1773″. G.B., I., F., U.S.A.

C. *depressum* (Bailey).—Frond *depressed*, broader than long, constriction a deep, narrow, acute notch; segments about twice as broad as long, *angular at* *base, broadly rounded at ends,* smooth. U.S.A.

C. *granatum* (Bréb.).—Frond minute, somewhat longer than broad; constriction linear; segments broader than long, *rapidly tapering, truncato-triangular,* smooth; s.v. compressed; e.v. elliptic. L. 1-1234"; B. 1-1602". G.B., I., F.

C. *polygonum* (Näg. sp.).—Frond minute, about one-third longer than broad, constriction shallow, linear; segments *hexagonal,* sometimes punctate, *lateral margins and ends straight*; e.v. elliptic with *a broad rounded inflation at each side.* = *Euastrum polygonum* (Näg.). G.

C. *Phaseolus* (Bréb.).—Frond in f.v. about as long as broad, constriction deep, linear; *segments reniform,* smooth; e.v. *elliptic,* with a *slight conical projection at each side.* L. 1-787"; B. 1-833". = *E. depressum* (Näg.)? G.B., I., F.

C. *Papilio* (Menegh.). — "Segments smooth, *triangular,* with rectangular apex, sides very slightly sinuato-undulate, lateral angles produced, acute; e.v. *linear with a lobe at middle of each side.*" *Euastrum? Papilio* (Kg.). G., Italy.

C. *Nægelianum* (Bréb.).—Frond in f.v. slightly longer than broad, constriction deep, linear; segments broad at the base, *rapidly narrowing upwards, sides with several minute sinuations, ends broadly truncate, straight or very slightly undulate,* obscurely punctate; e.v. elliptic, sometimes somewhat inflated at the sides. = *Euastrum* (*Cosmarium*) *crenatum* (Näg.). F., G.

C. *tetragonum* (Näg. sp.).—Frond in f.v. about twice as long as broad, *oblong,* constriction linear; segments *subquadrate,* somewhat narrowing from the base, sides and end each with *three slight sinuations,* those of the ends rather smaller, in each half one large central granule; s.v. segments *oval,* rounded, constriction shallow. = *Euastrum tetragonum* (Näg.). I., G.

C. *venustum* (Bréb. sp.).—Frond somewhat longer than broad, constriction deep, linear; segments slightly narrowed upwards, *with two somewhat deep sinuations at the sides, ends broad, truncate, slightly concave at the centre.* = *Euastrum venustum* (Bréb.). F.

2† Margins of segments crenate or slightly undulate, surface not granulate.

C. *Meneghinii* (Bréb.).—Frond very minute, rather longer than broad, constriction linear; segments subquadrate, *bicrenate at the sides and ends,* smooth; e.v. elliptic. L. 1-853" to 1-735"; B. 1-1250" to 1-1176". = *C. bioculatum* (Menegh.), *Euastrum bioculatum* (Kg.), *E. angulosum* (Bréb.), *E. crenulatum* (Näg.). G.B., I., F., G., Italy, U.S.A.

C. *crenatum* (Ralfs).—Frond minute, not quite twice as long as broad, constriction linear; segments *obsoletely quadrate, crenate at the margin, flattened at ends,* surface punctate; e.v. elliptic. Sporangium orbicular, spinous; spines very short and stout, swollen at base, and divided at the apex. L. 1-474"; B. 1-678". = *Euastrum? sinuosum* (Kg.). G.B., I., F.

C. *undulatum* (Corda).—Frond rather larger than last, slightly longer than broad, constriction linear; *segments semiorbicular, ends and sides broadly rounded,* crenate or minutely undulate at margin; e.v. elliptic. Sporangium orbicular, spinous; spines elongate, slender, swollen at the base and divided at the apex. L. 1-416"; B. 1-571". (II. 33, spor. 34). = *Euastrum crenulatum, c* (Näg.)? G.B., I., F., U.S.A.

3† Fronds rough on the surface, with pearly granules, which give a denticulate appearance to the margin.

C. *tetraophthalmum* (Kg., Bréb.).—Frond about a third longer than broad, constriction deep, linear; segments *forming nearly two-thirds of a circle,* rough on the surface with *short and broad scattered pearly granules,* giving a crenate appearance to the margin; e.v. broadly elliptic. Sporangium orbicular, spinous; spines swollen at base, finely branched. L. 1-232"; B. 1-1326". G.B., I., G., F.

C. *Brébissonii* (Menegh.). — Frond somewhat longer than broad, constriction deep, linear; segments *semiorbicular,* rough all over with somewhat *elongate-conical* scattered pearly granules; e. v. elliptic. L. 1-285"; B. 1-460". = *C. margaritiferum* (Kg.)? G.B., I., F., G.

C. *conspersum* (Ralfs).—Frond about a third longer than broad, constriction deep, linear; segments *quadrilateral,* angles rounded, rough all over with *depressed* granules arranged in lines; e.v. elliptic. L. 1-162"; B. 1-357". = *C. Brébissonii* (Menegh.)? G.B., F.

C. *Ungerianum* (Näg.).—Frond large, rather longer than broad, constriction deep, linear; segments much inflated at the base, *angles and sides rounded, narrowing upwards, ends broadly truncate,* rough *at the margin,* with *a few large* *rounded pearly granules placed in lines, the disc punctate*; e. v. broadly elliptic, the large pearly granules *confined to the rounded extremities*, regularly disposed in a few evident lines, the intermediate *central space punctate*. "L. 1-37'''; B. 1-43'''." = *Euastrum* (*Cosmarium*) *Ungerianum* (Näg.). G.

C. *ovale* (Ralfs).—Frond very large, elliptic, nearly twice as long as broad, constriction very deep, linear; segments somewhat broader than long, *somewhat triangular, rounded at ends, rough near the margin, with a band of large pearly granules*, producing a dentate appearance, the *disc punctate*; e. v. elliptic. L. 1-139"; B. 1-240". G.B., F., U.S.A.

C. *præmorsum* (Bréb.).—Frond rather longer than broad, constriction deep, linear; segments *broadly reniform*, sides rounded, ends somewhat truncate, rough with pearly granules, *an annular series of which, more elevated than the rest, forms a ridge at the end bounding a circular depression*; e. v. elliptic. F.

C. *margaritiferum* (Menegh.).—Frond about as long as broad, constriction deep, linear; segments *reniform or semiorbicular, rough all over with round and scattered pearly granules*; e. v. *elliptic*. Sporangium orbicular, spinous; spines branched at apex. L. 1-566" to 1-306"; B. 1-694" to 1-416". (I. I.) = *Ursinella margaritifera* (Turpin), *Euastrum margaritiferum* (Ehr., Näg.), *C. punctulatum* (Bréb.)? G.B., I., F., G., Italy, U.S.A., Mexico.

C. *Portianum* (Archer).—Frond about one-third longer than broad, constriction *deep, wide*, somewhat round below, *isthmus forming a short neck; segments elliptic*, rough all over with *minute scattered pearly granules*; e. v. elliptic. L. 1-600"; B. 1-930". I.

C. *latum* (Bréb.).—Frond large, about as broad as long, constriction deep, sublinear; segments *reniform*, rough with rounded pearly granules *arranged in somewhat curved transverse lines*; e. v.? F.

C. *notabile* (Bréb.).—Frond about one-third longer than broad, constriction somewhat deep, acute; segments slightly longer than broad, *broadest at the base, gradually narrowing upwards, sides convex*, ends truncate, *rough all over* with broad pearly granules, giving a crenate appearance to the margin (endochrome in bands); e. v. oval, turgid. Sporangium orbicular, beset with numerous short stout spines, inflated at the base, and deeply divided at the apex. F., G.

C. *amœnum* (Bréb.).—Frond twice as long as broad, *sides parallel, ends rounded*, constriction deep, linear; segments rough with *crowded obtuse papilla-like* pearly granules; s. v. much compressed, about thrice as long as broad; e. v. elliptic. L. 1-568"; B. 1-1141". G.B., F., U.S.A.

C. *Botrytis* (Menegh.).—Frond rather longer than broad, constriction deep, linear; segments twice as broad as long, *broadest at base, narrowing upwards*, sides rather rounded, *ends truncate, rough all over* with scattered *rounded* pearly granules; e. v. *broadly elliptic*. Sporangium orbicular, spinous; spines elongate and slightly divided at the apex. L. 1-469" to 1-327"; B. 1-625" to 1-419". = *Heterocarpella Botrytis* (Bory), *C. deltoides* (Corda), *Euastrum Botrytis* (Ehr., Kg., Näg.), *E. angulosum* (Ehr.). G.B., I., G., F., Italy, U.S.A.

C. *protractum* (Näg. sp.).—Frond about as broad as long, constriction deep, linear; segments twice as broad as long, *inflated and broadest at the base, rapidly tapering into a somewhat evident neck, sides very concave*, ends abruptly truncate, rough all over with scattered pearly granules; e. v. broadly elliptic, *slightly inflated at the middle*, and gradually sloping to the rounded ends. L. 1-55''' to 1-33'''. = *Euastrum protractum* (Näg.). G.

C. *gemmiferum* (Bréb. in lit. c. ic.).—Frond in f. v. about as long as broad, constriction deep, sublinear; segments broadest at the base, gradually narrowing upwards, *sides convex, ends truncate*, rough all over with pearly granules, somewhat arranged in radiating lines, each segment furnished at the middle, *on both surfaces, with a rounded protuberance bordered with granules*; e. v. broadly elliptic, with the central truncate protuberance on each side. F.

C. *Turpinii* (Bréb.).—Frond about as long as broad, constriction deep, linear; segments twice as broad as long, somewhat triangular, *much inflated and broadly rounded* at the base, *rapidly attenuated, sides concave*, ends truncate, rough all over with scattered pearly granules, and with a central granulated protuberance; e. v. *narrow-elliptic*, with the central *broad truncate* protuberance on each side. = *Heterocarpella Didelta* (Turpin), *C. Didelta* (Kg.). F., G.

C. *biretum* (Bréb.).—Frond in f. v. about as long as broad, constriction deep, linear; segments *quadrilateral or subhexagonal, narrowest at the base and dilated upwards*, convex or somewhat truncate at ends, rough all over with small granules *arranged somewhat in* *lines*; e. v. with *a rounded lobe on each side* and rounded at ends. L. 1-333″; B. 1-372″. G.B., F. Var. *triquetrum* (Bréb.): e. v. with three rounded angles, sides deeply sinuous!

C. *Broomei* (Thwaites). — Frond in f. v. about as long as broad, constriction deep, linear; segments *quadrilateral, ends straight*, angles rounded, rough all over with *minute* granules; e. v. twice as long as broad, slightly inflated at the middle and rounded at the ends. Sporangium *orbicular, smooth.* L. 1-500″; B. 1-540″. (I. 7.) G.B., F., U.S.A.

C. *cœlatum* (Ralfs). — Frond in f. v. about as long as broad, suborbicular, constriction deep, linear; *segments semiorbicular*, with *six broad crenatures at margin*, rough *at margin* with scattered pearly granules, and *at the centre* with granules *somewhat concentrically arranged*; e. v. twice as long as broad, with a broad inflation at each side. L. 1-921″ to 1-581″; B. 1-1024″ to 1-608″. (II. 26.) G.B., I., F.

C. *ornatum* (Ralfs). — Frond in f. v. about as long as broad, constriction deep, linear; segments semiorbicular or subreniform, with *a central truncate projection at the ends produced by the continuation of a central inflation, rough towards the margins and on the inflation* with pearly granules; e. v. with *a rounded lobe on each side.* Sporangium orbicular, spinous; spines elongated, dilated at the base, and slightly divided at the extremity. L. 1-613″; B. about the same. G.B., F., U.S.A.

C. *Sportella* (Bréb.).—Frond about as long as broad, constriction deep, linear; segments reniform, *with a central truncate projection at the ends, its angles slightly dilated and denticulate*, rough all over with scattered pearly granules. F.

C. *Corbula* (Bréb.). — Frond about as long as broad, constriction deep, linear; segments subreniform, *a central truncate projection at the ends with its angles slightly dilated and minutely denticulate*; furnished *at the centre of each segment with a circular protuberance bordered with granules, and rough thereon and towards the margins* with scattered pearly granules. F.

C. *commissurale* (Bréb.).—Frond small, in f. v. one-third broader than long; constriction very deep, rounded; segments *narrow-reniform, with a central somewhat truncate projection*, produced by the continuation of the central inflation, *rough on the inflation and on the extremities* with somewhat large pearly granules; e. v. three times longer than broad, *constricted between the central inflation and the rounded extremities.* Sporangium as in *C. ornatum.* L. 1-923″; B. 1-663″ to 1-609″. G., B., F. β *acutum* (Bréb.), angles sharper.

C. *cristatum* (Ralfs). — Frond in f. v. as long as broad, orbicular, constriction deep, linear; segments *semiorbicular*, margined by a series of *obtuse papilla-like pearly granules*, and having at the centre of each *a circular granulate inflation*; e. v. linear, *truncate at ends*, with a slight central inflation at each side. L. 1-700″; B. 1-653″. G.B., F.

C. *pluviale* (Bréb. in lit. c. ic.).—Frond about one-third longer than broad; constriction a *shallow wide notch*; segments *subovate*, gradually tapering, ends rounded, or broadly rotundato-truncate, *rough all over with minute granules*; e. v. elliptic. F.

2* *Frond not compressed; central constriction rarely a deep, never a linear, incision, but merely the result of the form of the contracted bases of the segments; e.v. circular, or, very rarely, compressed.*

† Frond rough with pearly granules, which give a denticulate appearance to the outline.

C. *Colpopelta* (Bréb. in lit. c. specimine). —Frond rather more than twice as long as broad; *constriction a shallow contraction*; segments somewhat widening upwards from the base, *oval, sides and ends broadly rounded, very minutely granulate*, granules scattered; e. v. circular. F.

C. *cylindricum* (Ralfs).—Frond minute, in f. v., about twice as long as broad; segments subquadrate, *narrower at the junction and gradually widening upwards, ends truncate*, rough all over with pearly granules somewhat *arranged in lines*; e. v. circular. L. 1-588″; B. 1-1060″. (III. 16, e. v. 17.) = *Penium Ralfsii* (Kg.). G.B., I., F.

C. *striolatum* (Näg. sp.).—Frond in f. v. about twice as long as broad, elliptic; constriction *a shallow rounded sinus*; segments with *sides and ends broadly rounded*, pearly granules *arranged in lines* and giving the margin a *crenate* appearance, *except at the central sinus, which is smooth.* L. 1-16‴; B. 1-33‴. = *Dysphinctium striolatum* (Näg.). G.

C. *orbiculatum* (Ralfs).—Frond minute, in f. v., twice as long as broad; constriction deep; *segments spherical, rough all over*, except at the neck-like contraction, with pearly granules; e. v. circular.

Sporangium orbicular, spinous; spines short, stout, conical. L. 1-498" to 1-454"; B. 1-750". = *Penium orbiculatum* (Kg.). G.B., F.

2 † Frond smooth.

C. *moniliforme* (Ralfs). — Frond minute, in f. v. twice as long as broad; constriction deep; *segments spherical, smooth*; e. v. circular. L. 1-617"; B. 1-1131". = *Tessarthronia moniliformis* (Turp.), *Tessarthra moniliformis* (Ehr.). G.B., I., F., G.

C. *connatum* (Bréb.). — Frond large, in f. v. about one-half longer than broad; constriction shallow; *segments about two-thirds of a circle*, coarsely *punctate*, and with a distinct, sometimes *striated, border*; e.v. circular. L. 1-285"; B. 1-1155". = *Dysphinctium Meneghinianum* (Näg.). G.B., F., U.S.A.

C. *Cucurbita* (Bréb.). — Frond in f. v. about twice as long as broad; constriction a shallow groove; segments *subcylindrical, or somewhat oval*, with rounded ends; e. v. circular; e. f. *punctate, the puncta scattered.* L. 1-586"; B. 1-1155". = *Penium clandestinum* (Kg.). G.B., I., F., G.

C. *Palangula* (Bréb.).—Frond in f. v. about two and a half times as long as broad; constriction a shallow groove; segments *cylindrical*; *ends obtuse*; e. v. circular; e. f. *minutely punctate*, the puncta *arranged in transverse lines.* F.

C.? *cruciferum* (De Bary). — Frond minute, in f. v. about twice as long as broad; constriction an extremely shallow groove; segments *subcylindrical*; ends broadly rounded; *endochrome composed of four broad plates cutting each other at right angles*; e. v. circular, *endochrome cruciform*; e. f. *not punctate.* L. 1-143'"; B. 1-287'". G.

C. *Thwaitesii* (Ralfs).—Frond in f. v. two or three times longer than broad; constriction a very shallow groove; segments subcylindrical, with rounded ends; *endochrome scattered*; e. v. *circular, or very slightly compressed*; e. f. *not punctate*, or puncta very indistinct. L. 1-357"; B. 1-801". = *Penium crassiusculum* (De Bary)? G.B., F., G., U.S.A.

C. *curtum* (Bréb.). — Frond in f. v. rather more than twice as long as broad; constriction very shallow; *segments attenuated and rounded at ends; endochrome in fillets*; e. v. circular, endochrome radiate. L. 1-465"; B. 1-1064". = *Penium curtum* (Bréb., Kg.), *Dysphinctium Regelianum* (Näg.)? G.B., F., G.

C. *attenuatum* (Bréb.).—Frond in f. v. fusiform, three, or sometimes four, times longer than broad; constriction very shallow; *segments conical, rapidly attenuated, ends angular, obtuse*; e. v. circular; e. f. *punctate.* L. 1-420"; B. 1-1099" to 1-1068". G.B., F.

C. *parvulum* (Bréb.).—Frond minute, in f. v. ovato-elliptic, about one and a half times longer than broad; central *constriction a very shallow groove; segments tapering, ends broadly rotundato-truncate*; e. f. *not punctate.* F.

C. *turgidum* (Bréb.). — Frond very large, in f. v. oval, *turgid*, rather more than twice as long as broad; constriction *a shallow sinus*; segments somewhat tapering, *broadly rounded*; e. v. circular; e. f. punctate. L. 1-126"; B. 1-249". = *Pleurotænium turgidum* (De Bary). G.B., F., G.

C. *De Baryi* (nobis). — Frond in f. v. about twice as long as broad; constriction a *wide shallow notch*; segments cylindrical, with broadly rounded ends; *endochrome arranged in parietal indented bands*; e. v. circular; e. f. minutely punctate or puncta absent. = *Pleurotænium Cosmarioides* (De Bary). G.

With great deference, we place the above species here, as described by M. de Bary, coinciding with M. de Brébisson in thinking the disposition of the endochrome not sufficiently constant to form the genus Pleurotænium.

Genus XANTHIDIUM (Ehr.). — Frond deeply constricted; segments broader than long, *compressed, entire, spinous*, having *a circular, cylindrical or conical projection on both surfaces near the centre*, which is tuberculated or dentate, or entire; end view *elliptic.*

* *Spines divided at the apex.*

XANTHIDIUM *armatum* (Bréb.). — Frond large, in f. v. twice as long as broad; constriction deep, *linear*; segments *broadest at the base*; ends rounded or somewhat truncate; *spines in pairs, principally marginal, short, stout, terminated by three or four diverging points*; central projections cylindrical, truncate, the *border dentate*; e. f. punctate. "Sporangium large, orbicular, with depressed tubercles; perhaps immature" (Ralfs). L. 1-180"; B. 1-270". (I. 27, 28.) = *Zygoxanthium Echinus* (Kg.). G.B., I., F., G., U.S.A.

X. (?) *Artiscon* (Ehr.).—Frond in f. v. about as long as broad; constriction forming a *wide notch*; segments *narrowed at the base*, with broadly rounded ends; spines *numerous, restricted to the outer margin, scattered, elongate*, stout, terminated by three or four diverging points. = *Asteroxanthium Arctiscon* (Kg.). G.

2 * *Spines subulate.*

X. *aculeatum* (Ehr.). — Frond in f. v. broader than long; constriction deep, linear; segments somewhat *reniform*; spines *subulate, short, scattered, chiefly marginal*; central protuberance *cylindrical*, truncate, border *minutely dentate*. L. (not including spines) 1-380″; B. 1-1347″ to 1-393″. = *Zygoxanthium aculeatum* (Kg.). G.B., I., F., Italy, G.

X. *Brebissonii* (Ralfs).—Frond in f. v. broader than long; constriction deep, acute, not linear; segments *subelliptic*, sometimes irregular; spines *subulate, geminate, marginal*; central protuberance *cylindrical*, truncate, border *minutely dentate*. L. (not including spines) 1-416″; B. 1-408″ to 1-365″. = *X. bisenarium* (Ehr.), *Zygoxanthium aculeatum* (Kg.). *β*, segments broader and more irregular, spines somewhat irregular and unequal. G.B., I., F., G., U.S.A.

X. *fasciculatum* (Ehr.).—Frond about as long as broad; constriction deep, linear; segments somewhat *reniform or subhexagonal*, twice as broad as long; spines slender, *subulate, geminate, marginal, in four or six pairs*; central protuberance short, *conical*, somewhat truncate. *a*, segts. with four pairs of spines. = *X. antilopæum* (Bréb.), *X. polygonum* (Hass., Bréb.). L. (not including spines) 1-454″ to 1-350″; B. 432″ to 408″. *β*, segts. with six pairs of spines. = *X. fasciculatum*, var. *polygonum* (Ehr.), *X. fasciculatum* (Hass., Bréb.). L. 1-481″; B. 1-516″. G.B., I., F., G., Italy, U.S.A.

X. *cristatum* (Bréb.). — Frond rather longer than broad; constriction deep, linear; segments *subreniform, or truncate at ends*; spines straight or *curved*, subulate, marginal, *one at each side, at the base of the segment, solitary*, the *others geminate*, in four pairs; central protuberance short, *conical*. *a*, segts. reniform, spines scarcely curved. L. (not including spines) 1-357″; B. 1-499″. (II. 18 & 23.) *β*, segments truncate at ends, spines uncinate. L. 1-469″; B. 1-625″. G.B., I., F., U.S.A.

X. *Smithii* (Archer).—Frond minute, in f. v. about as long as broad; constriction a wide notch; segments twice as broad as long, *trapezoid*, lower margin somewhat convex, sides narrowing upwards and straight, ends broad and straight, angles rounded, *each of the four angles presenting a pair of somewhat divergent, short, minute, acute spines*; s. v. constriction shallow, obtuse; segments with rounded sides, ends truncate, *each upper angle furnished with a minute spine, beneath each of which, about half way down, there occurs another similar spine*, all the spines somewhat divergent; e. v. subelliptic, or broadly fusiform, *ends blunt, rounded, furnished with three minute spines, none on the sides*; central protuberance *a minute tubercle*, apparent always in this view, but in s. v. sometimes hidden by the projecting central spines. L. 1-1166″; B. 1-1272″. G.B.

Genus ARTHRODESMUS (Ehr.).—Frond deeply constricted; segments compressed, *either* with *four prominent angles* and a single or geminate *spine, or a tooth, at each angle, or* having *one spine* or acute tooth only, *on each side*, at each upper or outer extremity; without a central projection; e. v. *elliptic or fusiform.*

* *Segments with four prominent angles and a simple or geminate spine, or an acute tooth, at each angle.*

Arthrodesmus *octocornis* (Ehr., Hass., Bréb.). — Frond smooth, minute, about as long as broad; constriction a wide notch; segments much compressed, *trapezoid*, each angle terminated by *one or two straight, subulate, acute spines*, the intervals between the angles concave. *a*, spine solitary at each angle. L. 1-1351″; B. 1-1538″. (I. 30.) *β* larger, spines geminate at each angle. L. 1-1020″; B. 1-906″. (I. 29.) = *Micrasterias octocornis* (Menegh., Kg.), *Xanthidium octocorne* (Ehr., Ralfs). G.B., I., F., G., Italy, U.S.A.

A. *bifidus* (Bréb.). — Frond smooth, very minute, about as broad as long: segments *somewhat arcuate, inner margin convex, outer concave*, extremities divergent, *emarginate, each angle terminating in an acute tooth*; e. v. compressed, fusiform, with a short acute spine or tooth at each end. F.

2* *Segments with a single acute tooth or spine at each side.*

A. *minutus* (Kg.).—Frond very minute, smooth, two or three times longer than broad; constriction a minute acute notch; segments *narrow, lateral margins parallel,* ends roundly concave, angles slightly produced into minute spines directed upwards. F., G.

A. *Pittacium* (Bréb. sp.).—Frond minute, smooth, two or three times longer than broad; constriction a minute acute notch; segments very *slightly inflated at the base, sides curved,* end margin roundly concave, angles acute. = *Euastrum Pittacium* (Bréb.). F.

A. *Incus* (Hass.). — Frond minute, smooth, as long as or longer than broad; constriction a deep notch or sinus; segments with *inner margin turgid, outer truncate,* spines subulate, acute. Sporangium orbicular, spinous; spines subulate. G.B., I., F., G., U.S.A. *a*, segments somewhat semiorbicular, connected by a distinct neck, spines diverging. L. 1-1100″ to 1-1660″; B. 1-1960″ to 1-1420″. *β*, segments gibbous near the base, spines parallel or converging. (III. 36.) L. 1-833″; B. 1-1116″.

A. *subulatus* (Kg.).—Frond minute, smooth, about as long as broad; constriction a wide acute-angled notch; segments *broadly fusiform,* spines horizontal, *straight,* slender, subulate; *ends convex.* G., U.S.A.

A. *convergens* (Ehr.).—Frond smooth, broader than long; constriction deep, acute; segments *elliptic,* each having its *lateral spines curved towards those of the other; ends convex.* L. 1-1539″ to 1-598″; B. 1-1477″ to 1-584″. = *Staurastrum convergens* (Menegh.), *Euastrum convergens* (Näg.). G.B., I., F., G., U.S.A.

Genus STAURASTRUM (Meyen).—Frond more or less deeply constricted at the middle; segments broader than long, often provided with spines or processes; end view *angular or radiate, or circular with a lobato-radiate margin,* or very rarely *compressed with a process at each extremity.*

* *Segments in f. v. with each of the opposite lateral extremities furnished with a mucro or a simple subulate acute awn or spine, which in e. v. terminates the angles, and without others intermediate.*

† Segments smooth, angles in e. v. inflated, sides concave.

STAURASTRUM *dejectum* (Bréb.).—Segments in f. v. *lunate or elliptic,* smooth, mucrones or awns directed upwards, parallel or convergent; e. v. with three or four angles, *angles inflated, mammillate,* terminated by a mucro or awn, sides concave at the centre. Sporangium orbicular, at first covered with minute hair-like spines, afterwards beset with stout subulate spines, and placed between the deciduous empty fronds. L. 1-833″; B. 1-757″. = *Goniocystis* (*Trigonocystis*) *mucronata* (Hass.). *a*, segments externally lunate, awns directed outwards; *β*, segments elliptic, awns parallel; *γ*, awns converging. G.B., I., F., U.S.A.

S. *apiculatum* (Bréb.).—Segments in f. v. somewhat turbinate, smooth, opposite lateral extremities rounded, *external margin straight,* furnished *at each side on the upper outer margin near the lateral extremities with a simple, short, subulate, acute spine directed upwards*; e. v. with three angles, angles inflated, mammillate, terminated by a short acute spine, sides concave. Sporangium orbicular, beset with conical spines, enlarged at the base and obtuse at the apex. F.

S. *Dickiei* (Ralfs).—Segments in f. v. subelliptic, *turgid,* smooth; spines short, *curved,* acute, converging with those of the opposite segment; e. v. with three angles, angles *inflated,* rounded, terminated by a spine, sides concave at the centre. L. 1-855″; B. 1-929″. G.B., I., F.

S. *brevispina* (Bréb.).—Segments in f. v. elliptic or somewhat reniform, *very turgid,* smooth; mucrones *minute, inconspicuous*; e. v. with three angles, angles inflated, broadly rounded, terminated by an inconspicuous mucro, sides concave at the centre. L. 1-502″; B. 1-510″. G.B., I., F.

S. *cuspidatum* (Bréb.).—Segments in f. v. *fusiform,* or truncate on outer margin, *connected by a long narrow band,* smooth; awns subulate, straight, acute, parallel or somewhat converging; e. v. with three or four angles, angles inflated, mammillate, terminated by an awn, sides concave at the centre. Sporangium orbicular, covered all over by the enlarged bases of the few spines, which are ultimately much attenuated and acute. L. 1-883″; B. 1-1000″. (I. 31–34.) = *Phycastrum cuspidatum* (Kg.), *P. spinulosum* (Näg.). G.B., I., F., G., Italy.

S. *aristiferum* (Ralfs). — Segments

smooth, in f. v. prolonged at *each lateral extremity into a mammillate projection,* which is terminated by a subulate, acute, straight awn, the awns divergent; e. v. with three or four angles; angles inflated, mammillate, terminated by an awn, sides deeply concave at the centre. L. 1-657″; B. 1-1064″. G.B., F., U.S.A.

2 † Segments smooth, angles in e. v. not inflated, sides straight, or nearly so.

S. *O'Mearii* (Archer). — Segments smooth, in f. v. somewhat *cuneiform, gradually widening upwards, outer margin truncate,* awns acute, divergent; e. v. with three or four acute angles terminated by an awn, *sides straight.* Sporangium orbicular, spinous; spines subulate, acute, ultimately somewhat inflated at the base. *a*, e. v. with four angles, awns comparatively short. L. 1-1866″; B. 1-2500″. *β*, e. v. with three angles, awns longer. L. 1-1750″; B. 1-2300″. I.

S. *minus* (Kg.). — Segments smooth, *very minute*, in e. v. with *five angles,* each terminated by a *very minute acute spine*; sides straight. G.

S. *glabrum* (Kg.).—Segments smooth, in f. v. cuneate, ends concave or straight, spines slender, mucro-like; e.v. with three mucronate angles, *sides concave.* I., G.

3† Segments rough with minute granules.

S. *lunatum* (Ralfs).—Segments in f. v. *externally lunate,* the inner margins convex, the outer somewhat truncate, and rough with minute granules; spines subulate, acute, *curved, obliquely directed outwards and upwards*; e. v. with three inflated rounded angles, terminated by a spine, sides concave at the centre. L. 1-856″; B. 1-686″. G.B.

S. *granulosum* (Ralfs).—Segments in f. v. *broadly fusiform,* granulate, lateral extremities pointed, *mucronate*; e. v. with three *subacute mucronate angles,* sides convex. = *Desmidium granulosum* (Ehr.), *S. acutum* (Bréb.). F., G.

2 * *Segments in f. v. with each of the opposite lateral extremities furnished with a mucro or a simple subulate spine, which in end view terminates the angles, and is accompanied by others intermediate of a similar character.*

S. *pungens* (Bréb.).—Segments in f. v. externally lunate, the inner margin curved, the outer truncate, smooth; the lateral marginal spines subulate, *curved, directed obliquely outwards and upwards, with six other spines on the outer margin, also directed outwards*; e. v. with three angles, each terminated by a spine, and with two others at its base *on the upper surface, and divergent at opposite sides,* sides nearly straight or slightly convex. G.B., F., U.S.A.

S. *cristatum* (Näg. sp.).—Segments in f. v. broadly elliptic, inner margin somewhat more turgid than the outer, submammillate at each side, *terminated by a mucro or short spine,* and possessing on the outer margin *a few others directed towards the angles*: e.v. with three subacute mucronate angles; *sides convex, with an inwardly curved, submarginal, single series of short mucro-like spines* directed towards the angles, sometimes wanting near the middle. L. 1-540″; B. 1-543″. = *Phycastrum (Pachyactinium) cristatum* (Näg.), *Staurastrum nitidum* (Archer). I., G.

3 * *Segments with each of the opposite lateral extremities furnished with a bifid or forked spine, its subdivisions subulate, acute, in e. v. terminating the angles, and appearing as a mucro-like spine, with or without intermediate spines.*

S. *Avicula* (Bréb.).—Segments in f. v. triangular or cuneate, *ends truncate,* smooth, with *a single forked spine on each side*; e. v. with three inflated angles, the bifid spine appearing as a mucro, sides concave. L. 1-967″; B. 1-948″. (III. 18, e.v. 19.) G.B., F.

S. *denticulatum* (Näg. sp.).—Segments in f. v. subelliptic, inner margin somewhat more turgid than the outer, both *undulate or toothed* in a scolloped manner, with *an unequally forked or geminate spine on each side, the upper longer than the lower, the lateral projections having a series of transverse rows of minute granules*; e. v. with three *subacute angles,* the spine appearing as a mucro, sides slightly concave at the centre, the *margin toothed* as mentioned before. "L. 1-70‴; thickness 1-55‴." = *Phycastrum denticulatum* (Näg.). G.

S. *armigerum* (Bréb.).—Segments in f. v. turgid on inner margin, outer truncate, smooth, with a *forked spine on each side, and a few simple or forked, sometimes minute, spines disposed at equal intervals between, on the outer margin*; e. v. with three angles, the bifid spine appearing as a mucro, and the intermediate spines *projecting on each side.* Sporangium orbicular, spines numerous, elongate, sublinear, forked at the apex. = S. *spinosum* (Ralfs). G.B., I., F.

S. *monticulosum* (Bréb.).—Segments in f. v. broadly elliptic, smooth, with a forked spine on each side, and at the end *six stout conical projections directed upwards, each terminated by an acute spine;* e. v. with three or four *acute* angles, sides concave, the *terminal projections extending on each side, confluent at their bases, from beneath which a minute, subulate, spine-like projection arises* between them and each angle. L. 1-500″; B. 1-700″. =*Stephanoxanthium monticulosum* (Kg.). G.B., I., F.

S. *Ehrenbergianum*.—The longitudinal outline of the segments obliquely oval, the inner margin convex, diverging, the outer margin very convex and broadly truncate at the ends; the sides in e. v. slightly undulate, membrane smooth, having at each angle a large spine, divided to the middle, consisting of two legs, and on the terminal surface three pairs of such spines, and between each of them and the angles a pair of smaller simpler spines. = *Phycastrum Ehrenbergianum* (Näg.). "L. 1-66‴; thickness 1-70‴." We have not seen a drawing of the above species, and give the above description following as nearly as possible Nägeli's own words, inserting it here as most probably its most fitting place.

4* *Segments with numerous simple acute spines, in f. v. no one in particular terminating the opposite lateral extremities; e. v. angles entire, rounded, the spines scattered.*

S. *hirsutum* (Bréb.).—Segments in f. v. *semiorbicular, separated by a linear constriction, covered with very minute, very numerous, close-set hair-like spines*; e. v. with three broadly rounded angles, the spines evenly and numerously scattered; sides slightly convex. Sporangium orbicular, beset with short spines, branched at the apex. L. 1-676″ to 1-468″; B. 1-833″ to 1-680″. =X*anthidium hirsutum* (Ehr., Kg.), *Goniocystis* (*Trigonocystis*) *muricata* (Hass.). G.B., I., F., U.S.A.

S. *pilosum* (Näg. sp.).—Segments in f. v. *obliquely elliptic,* slightly divergent, the outer margin more turgid than the inner; e. v. with three rounded angles, sides concave; scattered all over, except a small space at the centre, with *extremely fine hair-like spines, minutely capitate at their extremities;* surface between the spines smooth. "L. 1-55‴; thickness 1-66‴." *Phycastrum pilosum* (Näg.). M. de Brébisson is disposed to doubt the accuracy of Nägeli's drawing (*Einzell. Alg.* 8 A. fig. 4), the spines are indeed so very curious.

S. *Brebissonii* (nobis).—Segments in f. v. *ovato-lanceolate,* the lateral extremities rounded and furnished thereon with *numerous short, close-set, hair-like spines, otherwise smooth*; e. v. with three broadly rounded angles, the spines *confined to the extremities,* sides concave. = S. *pilosum* (Bréb.). F. We are obliged to alter the specific name of this species, —*pilosum* having been employed by Nägeli before for the preceding species.

S. *erosum* (Bréb).—Segments in f. v. *elliptic,* the lateral extremities furnished with numerous *extremely short acute spines,* sometimes inconspicuous, surface *granulated all over*; e. v. with three broadly rounded angles, the spines confined to the angles, sides concave. F.

S. *echinatum* (Bréb.).—Segments in f. v. elliptic, furnished with *numerous spines, somewhat broad at their base, exceedingly acute, chiefly confined to the outer margin*; e. v. with three angles; angles and sides broadly rounded, *bordered all round by the spines.* F.

S. *teliferum* (Ralfs).—Segments in f. v. *elliptic or subreniform,* furnished with a few scattered, elongate, *subulate, acute spines*; e. v. with three broadly rounded angles, *the spines scattered, chiefly confined to the extremities,* surface between the spines smooth, sides concave. Sporangium orbicular, beset with numerous elongate linear spines, forked at the apex. L. 1-597″; B. 1-643″. (III. 20, e. v. 21.) G.B., I., F.

S. *Hystrix* (Ralfs).—Segments in f. v. *subquadrate,* extremities somewhat rounded, *end margin nearly straight,* furnished with a few scattered, subulate, acute spines, *chiefly confined to the lateral extremities*; e. v. with three or four broadly rounded angles, the spines scattered, chiefly confined to the extremities, sides concave. L. 1-1075″ to 1-1020″; B. 1-1165″ to 1-954″. G.B.

5* *Segments with numerous short, truncate, emarginate, scattered spines, principally confined to the margins: e.v. angles rounded; if angles spinous, no spine in particular conspicuously larger than the others terminating the angles.*

S. *spongiosum* (Bréb.).—Segments in f.v. *semiorbicular,* furnished with scattered *short, stout, forked spines,* the spines at the lower basal angle of each rather larger than the others; e.v. with three somewhat rounded angles, sides *convex, and bordered all round with the spines.* L. 1-506″ to 1-418″; B. 1-523″ to 1-476″. (III. 22, e.v. 23.) = *Desmidium ramosum* (Ehr.), *Asteroxanthium ramosum* (Kg.), *Phycastrum Griffithsianum* (Näg.). G.B., I., F., G., U.S.A.

S. *scabrum* (Bréb.).—Segments in f.v. *subelliptic or broadly fusiform,* very rough or denticulate at the margin; e.v. with three rounded denticulate angles, sides straight, *bordered by minute, short, truncate emarginate spines.* F.

S. *asperum* (Bréb.).—Segments in f.v. broadly elliptic, very rough, with very *minute, short, truncate or forked spines* chiefly confined to the outer margin; e.v. with three rounded angles, sides *straight.* Sporangium orbicular, beset with numerous elongate spines, twice branched at the apex. L. 1-555″; B. 1-615″. G.B., I., F.

6 * *Segments without spines. e.v. angles rounded.*

† Frond smooth.

S. *muticum* (Bréb.).—Segments in f.v. *elliptic,* smooth, *without spines*; e.v. with three or four *broadly rounded angles,* sides concave. Sporangium beset with numerous elongate somewhat stout spines, forked at the apex. L. 1-674″; B. 1-686″. = *S. trilobum* (Menegh.), *Phycastrum muticum* (Kg.), *P. depressum* (Näg.). G.B., I., F., Italy, U.S.A.

S. *orbiculare* (Ralfs).—Segments in f.v. *semiorbicular,* smooth, without spines; e.v. with three broadly rounded angles, sides slightly concave. L. 1-1037″; B. 1-1106″. = *Desmidium orbiculare* (Ehr.), *Phycastrum orbiculare* (Kg.), *Goniocystis* (*Trigonocystis*) *orbicularis* (Hass.). G.B., I., F., G., Italy, U.S.A.

S. *coarctatum* (Bréb.).—Segments *oblong,* lateral extremities rounded, *inner margin convex, outer somewhat concave* at the centre (inversely reniform), smooth; e.v. with three *inflated* rounded angles, sides concave. F.

S. *pygmæum* (Bréb.).—Segments in f.v. *cuneiform,* outer margin slightly convex, smooth; e.v. with three *blunt* angles, sides *slightly convex.* Sporangium orbicular, " beset with protuberances bearing each two bifurcate spines at their summits." F., G.

2 † Segments having the projecting portions surrounded by annular transverse lines (rows of puncta or minute granules?).

S. *striolatum* (Näg. sp.).—Segments in f.v. *reniform,* divergent, *ends concave,* each of the *lateral portions crossed by about five transverse lines* (annular rows of closely set puncta or minute granules?); e.v. with three rounded angles, sides concave, each of the projections crossed as before by about five transverse lines, the central portion smooth. L. 1-100″. = *Phycastrum striolatum* (Näg.). G.

3 † Fronds rough superficially with scattered granules. (Sometimes *S. tricorne* might be thought almost to come in here; but the extremities in that species are more prolonged into distinct processes, usually colourless, and mostly divided at the apex. Here, also, might *S. asperum* and *S. scabrum* seem to fall in; but they are provided with very short and truncate spines on some part of their margin.)

S. *muricatum* (Bréb.).—Segments *subelliptic,* the outer margin more turgid than the inner, rough all over with *scattered conic granules*; e.v. with three angles, *both angles and sides broadly rounded.* L. 1-409″; B. 1-474″. = *Desmidium apiculosum* (Ehr.), *Xanthidium deltoideum* (Corda), *Phycastrum apiculosum* (Kg.), *P. muricatum* (Kg.), *Goniocystis* (*Trigonocystis*) *muricata,* β (Hass.). G.B., F., G., Italy.

S. *punctulatum* (Bréb.).—Segments in f.v. *elliptic,* equal, rough with scattered *puncta-like granules*; e.v. with three broadly rounded angles, sides *concave.* L. 1-704″; B. 1-881″. G.B., I., F.

S. *rugulosum* (Bréb.).—Segments in f.v. broadly *elliptic,* equal, *rough with scattered granules, giving a denticulate appearance to the margin, especially at the opposite lateral extremities*; e.v. with three broadly rounded *denticulate* angles, sides *straight* or nearly so. F.

S. *pileolatum* (Bréb.).—Segments in f.v. *quadrate,* the basal angles *rounded and rough with minute granules,* sides with *a broad shallow sinus,* the upper margin *terminating in three conspicuous, large, rounded, conical, very slightly divergent projections,* which are rough with minute granules; e.v. with three rounded angles, sides entire. F.

S. *Capitulum* (Bréb.).—Segments in f.v. *quadrate,* sides with a rounded sinus at the middle, the basal and upper angles crenated, rounded, *upper margin straight*;

e.v. with three broadly rounded crenated angles, sides nearly straight, each with a slight *shallow depression* or *constriction at the middle.* F.

S. *alternans* (Bréb.).—Segments in f.v. *elliptic* or *oblong,* two or three times as broad as long, separated by a wide sinus, *twisted, unequal*; rough with very minute pearly granules; e.v. with three *obtuse and rounded* angles, forming short not colourless rays, alternating with those of the other segment, sides concave. L. 1-1037"; B. 1-1106". (II. 16, 17.) = *Goniocystis* (*Trigonocystis*) *hexaceros* (Hass.), *S. dispar* (Bréb.)? G.B., I., F., U.S.A.

S. *dilatatum* (Ehr.). — Segments in f.v. *fusiform,* their lateral extremities obtuse, *equal,* rough with puncta-like pearly granules; e.v. with four *rotundato-truncate* angles, forming short, broad, not colourless rays, sides concave. L. 1-1201"; B. 1-1381". = *Phycastrum dilatatum* (Kg.), *Goniocystis* (*Staurastrum*) *dilatata* (Hass.). G.B., I., F., G., Italy, U.S.A.

S. *crenatum* (Bailey). — Segments in f.v. *fan-shaped in outline,* separated by a *wide rounded sinus,* inner margin *concave, smooth,* outer *semicircular, crenate*; e.v. with three rotundato-truncate *crenate* angles, sides concave, smooth. U.S.A.

7* *Segments with or without spines; in f. v. with spines (if any) few and scattered; in e. v. angles emarginate or bifid, or truncate and the extremities plane and quadrangular.*

S. *bifidum* (Ralfs).—Segments in f.v. . . . . ; in e.v. with *three acutely bifid or emarginate angles,* the teeth acute; sides concave. = *Desmidium bifidum* (Ehr.), *Phycastrum bifidum* (Kg.), nec *Goniocystis* (*S.*) *bifida* (Hass.). F., G.

S. *quadrangulare* (Bréb.).—Segments in f.v. *subquadrate,* with a *few short bifid or tooth-like spines spreading laterally,* otherwise smooth; e.v. with four *truncate and emarginate angles*; sides concave. L. 1-1157"; B. 1-1163". (III. 24, e.v. 25.) β, angles in e.v. broader, with *four teeth* at the extremity, and *two minute teeth on upper side* (Bréb.). G.B., F.

• S. *Cerberus* (Bailey).—Segments in f.v. *truncato-oblong,* smooth; the opposite lateral extremities *abruptly truncate, externally plane and quadrangular,* the angles drawn out into acute *spine-like extensions or teeth,* two projecting upwards and two downwards; e.v. with three *abruptly truncate* angles, extremities as in f.v. *plane* and quadrangular, the teeth at the angles divergent. U.S.A.

8* *Segments without spines; in f.v. and e.v. the angles terminated by either a conspicuous rounded nipple-like projection, or an enlarged rounded knob, or an elongate capitate process.*

S. *tumidum* (Bréb.).—Segments in f.v. *elliptic, turgid,* smooth; their margin striated, and their opposite lateral extremities furnished with a *rounded conspicuous nipple-like projection*; e.v. with three or four angles, the nipple-like projection terminating the angles, sides *convex*; e.f. punctate; gelatinous investment very evident. L. 1-200"; B. 1-250". = *S. orbiculare* (Menegh.), *Phycastrum tumidum* (Kg.). G.B., I., F.

S. *globulatum* (Bréb.). — Segments in f.v. *fusiform, capitate*; e.v. with three angles, each enlarged into a rounded *granulated knob,* sides nearly straight. (III. 26, e.v. 27.) F.

S. *bacillare* (Bréb.).—Segments in f.v. somewhat *arcuate, each divergent* from the opposite segment, somewhat attenuated, *finally capitate, smooth*; e.v. with from three to five capitate rays. = *Phycastrum bacillare* (Kg.). F.

9* *Segments in f.v. with the opposite lateral extremities each tapering into a single more or less elongate colourless process divided at the apex, which in e.v. terminates the angles, with or without intermediate simple or truncate spines.*

† Segments smooth.

S. *brachiatum* (Ralfs).—Segments in f.v. *smooth,* narrow below, widening upwards, ends truncate, the lateral *extremities each produced into a smooth,* elongate, straight, tapering, *divergent* process, bifid or trifid at the apex; e.v. tri- or quadriradiate, sides concave. L. 1-1111"; B. 1-1785". = *Goniocystis* (*S.*) *bifida* (Hass.), *Phycastrum Ralfsii* (Kg.). G.B., I., F., G.

2† Segments rough with superficial granules, those on the processes arranged in transverse lines. (*S. polymorphum* has sometimes a few inconspicuous scattered spines.)

S. *tricorne* (Bréb.).—Segments in f.v. *somewhat fusiform,* often twisted, rough with minute puncta-like granules, tapering at each side into a short usually colourless process, *blunt, or divided at the apex*; e.v. tri- or quadriradiate, processes short, usually colourless, sides somewhat concave. Sporangium orbicular, beset with spines ultimately branched at the apex. L. 1-1275" to 1-972"; B. 1-948" to 1-697". = *Desmidium hexaceros* (Ehr.). *Phycastrum tricorne* (Kg.), *P. trilobatum* (Kg.)? *P. hexaceros* (Kg.)?, *P. Ralfsii* (Näg.), *P. crenulatum* (Näg. in part). G.B., I., F., G., U.S.A.

S. *cyrtocerum* (Bréb.).—Segments in f. v. *subcuneate*, gradually widening upwards, truncate at the end margin, rough with minute granules, the lateral processes *incurved*, divided at the apex; e.v. triradiate, processes short, curved, sides slightly concave. L. 1-800"; B. 1-500". = *Phycastrum cyrtocerum* (Kg.). G.B., I., F., U.S.A.

S. *inflexum* (Bréb.).—Segments in f.v. *broadly elliptic, inner and outer margin turgid*, rough with minute granules, lateral processes *incurved, short*, divided at the apex; e.v. tri- or quadriradiate, processes short, sides concave. F.

S. *brachycerum* (Bréb.).—Segments in f.v. *ovato-lunate, inner margin turgid, outer equally rounded*, rough all over with minute granules, and on the outer margin *very rough* with minute, acute, short, almost spine-like granules; lateral processes incurved, divided at the apex; e. v. triradiate, processes short, straight, sides somewhat concave. F.

S. *polymorphum* (Bréb.). — Segments in f.v. *broadly elliptic or almost circular*, rough with minute granules (sometimes with a few minute scattered spines), processes *short, stout*, tipped by three or four *divergent* spines; e.v. with three, four, five, or six angles, each produced into a short stout process. Sporangium orbicular, beset with elongate spines, forked or branched at the apex. L. 1-1000"; B. 1-1157". (II. 20, 21, 24, 25, & 31.) G.B., I., F., U.S.A.

S. *gracile* (Ralfs).—Segments in f.v. *triangular, ends truncate*, rough with minute granules, tapering at each side into *elongate, straight, slender, horizontal* processes, terminated by three or four minute spines; e.v. triradiate, processes *straight*, sides concave. L. 1-773" to 1-539"; B. 1-348" to 1-372". (III. 28, e.v. 29.) = *Goniocystis* (*Trigonocystis*) *gracilis* (Hass.), *Phycastrum gracile* (Kg.). G.B., I., F.

S. *paradoxum* (Meyen). — Segments in f.v. *gradually widening upwards, the ends truncate*, rough with minute granules, processes straight, elongate, slender, *divergent*, trifid at the apex; e.v. tri- or quadriradiate, processes straight, sides straight or very slightly concave. L. 1-941"; B. 1-1165". = *Phycastrum paradoxum* (Kg.), *Goniocystis* (*S.*) *paradoxum* (Hass.). G.B., I., F., G., Italy, U.S.A.

3† Segments furnished with variously disposed spines, which are either simple, or short and notched at the apex.

S. *proboscideum* (Bréb.).—Segments in f.v. *broadly cuneiform*, ends somewhat convex, rough *with very minute, short, truncate spines, chiefly confined to the outer margin*, processes *short, thick*, trifid at the apex; e. v. triradiate; processes short, stout, sides concave. L. 1-555"; B. 1-500". = *S. asperum*, *β* (Ralfs, Bréb.). G.B., I., F.

S. *controversum* (Bréb.).—Segments in f.v. *elliptic or broadly fusiform*, sometimes irregular, furnished with scattered, *irregular, simple or notched spines*; processes short, *generally curved, spinulose*, terminated by minute spines; e. v. triradiate, the processes *twisted or curved*. Sporangium orbicular, spinous; spines twice branched. L. 1-972"; B. 1-886". *Goniocystis* (*Trigonocystis*?) *aculeatum* (Hass.). G.B., I., F.

S. *aculeatum* (Menegh.).—Segments in f.v. *broadly fusiform*, furnished with *thickly scattered simple or notched spines*; processes *elongate, spinulose, straight*, terminated by minute spines; e.v. 3–5-radiate, the processes *straight*, sides concave. L. 1-666"; B. 1-500". = *Desmidium aculeatum* (Eh.), *Phycastrum aculeatum* (Kg.), *Goniocystis* (*Trigonocystis*) *aculeatum* (Hass.). G.B., I., F., G., Italy.

S. *vestitum* (Ralfs).—Segments in f.v. *fusiform, outer margin bordered by minute emarginate spines*; processes *elongate, rough*, terminated by minute spines; e.v. triradiate, the processes elongate *straight*, sides concave, *furnished at the middle with a pair of conspicuous slender forked spines*, sometimes accompanied by a few others shorter either simple or notched. L. 1-625"; B. 1-384". (III. 30, e. v. 31.) G.B., I., F.

S. *oxyacantha* (Archer).—Segments in f.v. *broadly fusiform, rough with minute granules*, furnished *on the outer margin with six subulate acute depressed spines* (four of which are apparent in this view); processes elongate, *incurved*, the granules thereon arranged in transverse lines, terminated by three or four minute spines; e. v. triradiate, the processes elongate straight, sides somewhat concave, end furnished *at the middle with a pair of very slender extremely acute subulate* *spines* projecting to each side. L. 1-770"; B. 1-580" to 1-636". I.

10* *Segments in f.v. with the opposite lateral extremities terminating in one or two elongate colourless processes mostly divided at the apex; and in e.v. either tapering into a single process at each angle, and furnished with others between or above of a similar character definite in number, or the angles furnished with two short processes side by side and unaccompanied by others.*

† Segments at end view with the additional processes more than one for each angle, and placed on the margin or upper surface, and diverging laterally.

S. *furcatum* (Bréb.). — Segments smooth, in f.v. broadly elliptic, furnished at each opposite lateral extremity with a colourless bifid process, and with *six others similar and divergent on external margin* (four only of which are usually visible); e.v. with three acute angles, each tapering into a terminal process, and each bearing *two others on the upper surface, placed to each side*, and projecting laterally. L. 1-860"; B. 1-900".= *Xanthidium furcatum* (Ehr.), *Asteroxanthium furcatum* (Kg.), *A. bisenarium* (Kg.)? G.B., I., F.

S. *senarium* (Ehr.). — Segments smooth, in e.v. with three angles, each terminating in a short process tipped by minute spines, and *having six other short forked processes on the margins*, two at each side and projecting laterally, *and six others on the upper surface*, confluent at their bases, divergent at their extremities, and forked; sides straight. (II. 7.) = *Stephanoxanthium senarium* (Kg.). U.S.A.

S. *eustephanum* (Ehr.). — Segments granulate, in e.v. with three angles, each terminating in a short process tipped by minute spines, *without lateral processes*, but with six others confluent at their bases on the upper surface, divergent and forked. (II. 3.) = *Stephanoxanthium eustephanum* (Kg.). U.S.A.

S. *Ehrenbergii* (Corda).—"Corpuscles par paire, vus de côté, ovales; vus d'en haut, triangulaires, munis de six appendices terminaux et latéraux, et de deux autres appendices centraux, qui sont courts, blancs, en fourchette, mais à pointes divergentes" (Corda, 'Obs. Micr. des Animalcules de Carlsbad,' 1840). In Corda's figure the f. v. is somewhat like that of *S. furcatum*. The segments are broadly fusiform, the processes are all very short and stout, and the bifurcations very divergent (formed indeed *somewhat like the tail of a fish*). =*Xanthidium Ehrenbergii* (Corda, *l. c.*).

S. *articulatum* (Corda).—"Corpuscles ovales, par paire, munis aux deux bouts d'un appendice à deux cellules, qui se divise encore en forme de fourchette, et latéralement en deux appendices plus longs à quatre cellules, et une pointe en fourchette. Sur les deux côtés plats, se trouvent deux protubérances transversales, également pourvues de deux allongements cellulaires en fourchette" (Corda, *l. c.*). In Corda's figures the segments in f.v. are elliptic, the processes stout, elongate, transversely striated (by rows of granules?), bifurcate, the bifurcations recurved. =*X. articulatum* (Corda). Neither of the figures of the foregoing is explanatory; both, however, seem to be distinct species.

2 † Segments with the additional processes one for each angle, and placed on the upper surface immediately above those terminating the angles.

S. *furcigerum* (Bréb.). — Segments in f. v. twice as broad as long, separated by a deep constriction, *rough with pearly granules, terminating at each side in two elongate, stout processes, bifid at the apex, placed one above the other*, the inferior horizontal, the superior directed obliquely outwards and divergent, both having the granules thereon in transverse lines; e. v. with three or four angles, each extremity terminating in a process and having the other immediately above it on the upper surface, sides concave at the centre. L. 1-333"; B. 1-357" incl. processes. (III. 32, e. v. 33.) =*Didymocladon furcigerus* (Ralfs), *Asteroxanthium furcigerum* (Kg.), *Xanthidium coronatum* (Ehr.)?, *A. coronatum* (Kg.)? G.B., I., F., G., U.S.A.

S. *longispinum* (Bail. sp.). — Segments in f. v. triangular, truncate on outer margin, *smooth*, terminating at each side in two much elongated stout processes, *subacute at the apex*, placed one above the other, divergent; e. v. with three angles, each extremity terminated by a process and having the other immediately above it on the upper surface, side straight. = *Didymocladon longispinum* (Bailey). U.S.A.

3 † Segments with two processes from each angle placed side by side.

S. *læve* (Ralfs).—Segments in f. v. externally *lunate or somewhat cuneate*, with the ends somewhat protuberant, smooth, terminating at each side *in a pair of short stout processes placed side by side* (one only of which, however, is apparent), directed upwards and divergent, forked at the apex; e. v. with three or four angles, *each terminated by the pair of short processes separated by a rounded sinus*, sides deeply concave. L. 1-1220"; B. 1-2127". G.B., F.

11 * *Segments in f. v. with each opposite lateral extremity terminating in a colourless process, either short, rounded, and dentate, or elongate and entire at the end; e. v. circular, margined with from five to seven processes, or compressed, and with but two processes.* (S. polymorphum *sometimes has five rays, and the e. v. appears almost circular, but the extremities of the processes are not entire but tipped with minute spines.*)

† End view circular.

S. *sexcostatum* (Bréb.).—Segments in f. v. *suborbicular, furnished on each side with a short, broad, truncate, dentate process,* and with slight crenate elevations on the outer margin; e. v. *circular, bordered by five or six short, rounded, dentate, colourless marginal rays.* L. 1-661"; B. 1-833" to 1-694". = *Goniocystis (Pentasterias) Jenneri* (Hass.), *Stephanoxanthium sexcostatum* (Kg.). G.B., I., F.

S. *margaritaceum* (Menegh). — Segments in f. v. gradually widening upwards, rough with pearly granules, outer margin convex, produced at each side *into a colourless, more or less attenuate short process,* having the granules in transverse lines, *blunt and entire at the apex*; e. v. circular, bordered by from five to seven short, narrow, *obtuse*, colourless, granulate marginal rays. L. 1-1176"; B. 1-1000" incl. processes. (III. 34, e. v. 35.) = *Pentasterias margaritacea* (Ehr.), *Phycastrum margaritaceum* (Kg.), *Goniocystis* (*Pent.*) *margaritacea* (Hass.), *Phycastrum rotundatum* (Kg.). G.B., I., F., G., U.S.A.

S. *Arachne* (Ralfs).—Segments in f. v. *suborbicular*, rough with minute granules, lower margin turgid, outer convex, tapering at each side into an *elongate, slender, incurved process* having the granules thereon in transverse lines, *entire* at the apex; e. v. circular, bordered by five *slender, linear, colourless marginal rays.* L. 1-1020"; B. 1-652" incl. processes. = *Goniocystis* (*Pentasterias*) *arachnis* (Hass.), *Phycastrum Arachne* (Kg.), *P. radiatum* (Kg.)?. G.B., F.

2 † End view compressed.

S. *tetracerum* (Ralfs). — Segments in f. v. gradually widening upwards, rough with minute granules, outer margin truncate or concave, *tapering at each lateral extremity into an elongated, very slender, colourless* process, having the granules thereon in transverse lines, entire at the apex and divergent; e. v. *much compressed, with a process at each extremity.* L. 1-2703"; B. 1-1785". = *S. paradoxum* (Ehr.), *Goniocystis* (*S.*?) *paradoxum* (Hass.), *Phycastrum paradoxum* (Kg.). G.B., I., F., G., U.S.A.

[S. *enorme* (Ralfs) is omitted, this plant having been, as we think, shown by De Bary (*op. cit.*) to be a Polyedrium.]

2. Fronds distinctly, faintly, or not at all constricted at the middle, very rarely less than three times, mostly many times longer than broad. Sporangia smooth, and either spherical, elliptic, quadrate, or cruciform.

Genus TRIPLOCERAS (Bailey).—Frond very *elongate, straight, constricted at the middle*; segments with numerous whorls of knot-like projections, *ends three-lobed, lobes bidentate.* Endochrome with a terminal rounded clear space, in which are active granules.

TRIPLOCERAS *verticillatum* (Bailey). —Frond stout, suture prominent, segments about eight or ten times longer than broad, with numerous whorls of prominent, broad, truncate, *emarginate* projections. (III. 37.) = *Docidium verticillatum* (Ralfs). U.S.A.

T. *gracile* (Bailey). — Frond rather slender, suture prominent, segments ten or twelve times longer than broad, with numerous whorls of prominent, somewhat triangular, *roundly blunt* projections. = *Docidium verticillatum* (Ralfs). U.S.A.

Genus DOCIDIUM (Bréb.).— Frond *very elongate, straight, constricted at the middle*; segments with an inflation at the base (very rarely not so), often with others above, or with whorls of knot-like projections, *ends abruptly truncate*. Endochrome with a terminal rounded clear space at each end, in which are active granules.

DOCIDIUM *verrucosum* (Bailey). — Frond rather stout, suture forming a rim; segments five or six times longer than broad, with *numerous small equal undulations* due to so many whorls of small tubercle-like prominences; ends entire. U.S.A.

D. *nodosum* (Bailey). — Frond *stout*, suture forming a rim; segments three or four times as long as broad, with *four prominent inflated nodes, including the basal*, which is somewhat the largest, and which are due to so many whorls of knot-like prominences or large tubercles; ends entire; e. v. crenate. U.S.A.

D. *coronatum* (Bréb.). — Frond *stout*, suture forming a thickened projecting rim; segments four to six times as long as broad, *tapering*, regularly inflated upwards from the base, so as to produce an undulated margin, the basal inflation the most prominent, the others less so, and wanting towards the ends; ends *bordered by prominent tubercles, projecting all round*; e. v. circular, bordered by the tubercles; e. f. coarsely punctate. F.

D. *undulatum* (Bailey).—Frond *slender*, suture forming a minute rim, segments eight to ten times as long as broad, *with six or eight sinuations at regular intervals*, producing as many inflations besides the basal, which is not larger than the others; *ends and bases crenate*. U.S.A.

D. *Ehrenbergii* (Ralfs).—Frond slender, *linear*; suture forming a very sharply-defined rim; segments eight to twelve times longer than broad, *basal inflation having another smaller one above it*, sides otherwise straight, *parallel*; *ends crenate*, owing to a number of emarginations from the edge of the truncate extremities, from three to five of the crenatures being usually visible; e. f. punctate, or rough with minute granules. Sporangium suborbicular or elliptic, or slightly angular, smooth, placed between the deciduous empty fronds. Ciliated zoospores formed by segmentation of the cell-contents, and their emission effected through the opened apex of each of one, two, or three specially-formed lateral tubes arising from beneath the base of one of the segments (*vide suprà*, p. 716; III. 46, 47). L. 1-71″ to 1-59″; B. 1-1111″ to 1-961″. (II. 8 & 11.) = *Pleurotænium Ehrenberghii* (De Bary). G.B., I., F., G., U.S.A.

D. *clavatum* (Kg.). — Frond *slender*, suture scarcely prominent, segments eight or ten times as long as broad, slightly *clavate* near the ends, and *ultimately somewhat attenuated*, basal inflation sometimes solitary, sometimes having another slight one above it; ends *entire*; e. f. punctate. L. 1-65″; B. 1-813″. (II. 9.) = *Pleurotænium clavatum* (De Bary). G.B., I., F., G., U.S.A.

D. *nodulosum* (Bréb.). — Frond *very stout*, the thickened suture forming a projecting rim; segments four to six times as long as broad, scarcely attenuated, *regularly inflated at intervals* so as to produce an undulated margin, the basal inflation the most prominent, the others as they approach the ends less so, where they are indistinct or wanting; ends *entire*; e. f. coarsely punctate. L. 1-50″; B. 1-428″. = *D. crenulatum* (Ehr.), *Pleurotænium nodulosum* (De Bary). G.B., I., F., G., U.S.A.

D. *truncatum* (Bréb.). — Frond *stout*, the thickened suture forming a rim; segments three or four times longer than broad, *tapering*, basal inflation *solitary, sides otherwise gradually curved*; ends entire; e. f. punctate. = *Pleurotænium truncatum* (Näg., De B.). L. 1-81″ to 1-72″; B. 1-527″ to 1-429″. G.B., I., F., G.

D. *constrictum* (Bailey).—Frond *stout*, suture not prominent; segments five or six times longer than broad, *not attenuated, with four distinct equidistant sinuations* producing four equal gently curving prominences besides the basal inflation; ends entire. U.S.A.

D. *Baculum* (Bréb.). — Frond *slender*, suture not prominent; segments very many times longer than broad, basal inflation *very conspicuous, solitary, sides otherwise straight*, very *nearly parallel*, large granules of the endochrome in a single series; ends entire; e. f. without puncta. L. 1-111″; B. 1-1937″. (III. 38.) = *Pleurotænium Baculum* (De Bary). G.B., F., G., U.S.A.

D. *minutum* (Ralfs). — Frond slender, suture not prominent; segments four to six times longer than broad, *somewhat tapering, inflation obsolete, sides straight*, ends entire; e. f. without puncta. L. 1-212″; B. 1-1582″. = *Penium Ralfsii* (De Bary). G.B., I., F., G., U.S.A.

D. *hirsutum* (Bailey). — Frond rather slender, suture not prominent, segments four to six times as long as broad, *not tapering, inflation obsolete*, ends entire, *surface all over minutely spinous, or hirsute.* U.S.A.

Kützing (Sp. Alg.) describes one or two other species of Docidium; but the characters given seem hardly distinctive, and appear sometimes more like generic characters re-stated.

Genus TETMEMORUS (Ralfs).—Frond elongate, *straight*, cylindrical or fusiform, *constricted at the middle*; segments more or less tapering, not inflated at the base, *ends with an acute incision*, the subdivisions rounded, *otherwise quite entire.*

TETMEMORUS *Brebissonii* (Ralfs). — Frond about five or six times longer than broad; *in f. v. with parallel sides*, the constriction a very shallow groove; *in s. v. fusiform*, the constriction very slightly deeper; endochrome with a longitudinal series of light-coloured large granules; e. f. punctate, *the puncta in longitudinal rows.* L. 1-142″; B. 1-704″. (II. 12 & 13.) = *Closterium Brébissonii* (Menegh.), *Penium monile* (Kg.), *P. striato-punctatum* (Kg.)? G.B., I., F., G., Italy, U.S.A. *β, turgidus*, larger, stouter, constriction deeper. *γ*, —— (De Bary), smaller than either, otherwise externally similar, endochrome in longitudinal fillets.

T. *lævis* (Ralfs).—Frond smaller than last, scarcely one-half its length, about three or four times as long as broad; *in f. v. somewhat tapering*, the constriction a shallow depression; *in s. v. fusiform*; end sometimes with a hyaline lip-like projection extending beyond the notch; e. f. punctate, puncta faint but evident, *scattered.* Sporangium smooth, in f. v. at first quadrate, afterwards broadly elliptic; in s. v. compressed, enclosed in a central cell placed between the ultimately deciduous empty fronds. L. 1-374″ to 1-336″; B. 1-1244″ to 1-1073″. = *Penium* (*Tetmemorus*) *Brebissonii* (Kg.). G.B., I., F., G.

T. *minutus* (De Bary).—Frond minute, shorter than *T. lævis*, about three times longer than broad, *fusiform*, the constriction a very shallow groove; e. f. *without puncta.* L. 1-41‴; B. 1-118‴. G.

T. *granulatus* (Ralfs). — Frond somewhat longer than *T. Brebissonii*, about five or six times longer than broad; *in both f. v. and s. v. fusiform*, the constriction a very shallow groove, *ends with a hyaline lip-like projection* extending beyond the notch; endochrome with a longitudinal series of large granules; e. f. punctate, the *puncta scattered*, except near the constriction, where they are disposed in two transverse rows. Sporangium orbicular, smooth, margin finely striated, placed between the deciduous empty fronds. L. 1-130″; B. 1-649″. = *Penium* (*T.*) *granulatus* (Kg.). G.B., I., F., G., Italy, U.S.A.

Genus CLOSTERIUM (Nitzsch).—Frond *elongate, attenuate, more or less lunately curved or arcuate, entire*, not constricted at the middle, the junction of the segments marked by a pale transverse band. Endochrome often arranged in longitudinal fillets, and at each extremity having a terminal clear space, in which are active granules; e. f. smooth, or with longitudinal striæ, never granulate.

The subdivisions of this genus cannot always be rigidly adhered to, as certain species might sometimes seem to agree almost as well with another division as with that in which they are placed.

* *Frond scarcely tapering, the curvature very slight, gradual and equal; lower margin nearly straight or slightly concave; ends truncate or broadly rounded; e. f. with or without longitudinal striæ.*

CLOSTERIUM *didymotocum* (Corda).— Frond *stout*, six to ten times longer than broad, *nearly straight, very slightly tapering* to the extremities, upper margin slightly convex, *lower nearly straight or very slightly concave*, sometimes slightly inclined upwards at the end; *ends truncate, reddish*; large granules in a single series; e. f. reddish, especially near the ends, *striæ faint*; central suture evident, sometimes accompanied by two others dividing the frond into four portions. L. 1-65″; B. 1-813″. (III. 39.) G.B., I., F., G. *a*, three transverse sutures; *β*, one. = *C. subrectum* (Kg.), *C. Baileyanum* (Bréb.).

C. *obtusum* (Bréb.). — Frond minute, four to ten times as long as broad, nearly straight, *cylindrical, not tapering, upper and lower margin equally and but very slightly curved, ends obtusely rounded*; large granules, in a single series; e. f. smooth. F.

C. *Amblyonema* (Ehr.). — Frond *stout, very long,* twenty to twenty-five times as long as broad, *slightly curved, scarcely tapering,* upper and lower margins equally and but gently curved; *ends broadly rounded*; e. f. smooth. U.S.A.

2 * *Frond tapering, having the curvature slight: lower margin straight or very slightly concave, and slightly inclined upwards towards the rounded or subacute ends: e. f. with or without longitudinal striæ.*

C. *Lunula* (Ehr.).—Frond large, *stout,* five or six times as long as broad, *semilunate, upper margin very convex, lower nearly straight, somewhat inclined upwards towards the obtuse broadly rounded ends*; endochrome with the large granules numerous, scattered, fillets several, distinct; e. f. colourless, without markings, central suture not evident. L. 1-62″; B. 1-330″. = *Vibrio Lunula* (Müller), *Bacillaria Lunula* (Schrank), *Lunulina vulgaris* (Bory). G.B., F., I., G., Italy, U.S.A., Mexico.

C. *acerosum* (Ehr.). — Frond *slender,* six to fifteen times as long as broad, *linear-lanceolate,* gradually tapering, upper margin slightly convex, the lower nearly straight, slightly inclined upwards at the *conical ends*; large granules in a single central longitudinal series; fillets several, distinct; e. f. colourless, very faintly striated, central suture evident. L. 1-70″ to 1-58″; B. 1-1103″ to 1-510″. Sporangium orbicular, smooth, placed between the dehiscing deciduous empty fronds. = *Vibrio acerosus* (Schrank). G.B., I., F., G., U.S.A., Mexico.

C. *lanceolatum* (Kg.). — Frond stouter than *C. acerosum,* six to ten times longer than broad, *semilanceolate,* gradually tapering; upper margin convex, lower nearly straight, inclined upwards towards the *tapering subacute ends*; large granules in a single central series; fillets several, distinct; e. f. colourless, usually without markings, sometimes faintly striated, central suture evident. L. 1-64″; B. 1-453″. = *Cymbella Hopkirkii* (Moore). G.B., I., F., G., U.S.A.

C. *turgidum* (Ehr.). — Frond *stout,* eight to twelve times as long as broad, *semilanceolate, slightly tapering,* more curved than either of the preceding, upper margin convex, *with a depression near each extremity,* lower margin concave, inclined upwards towards the *rounded ends*; large granules, in a single longitudinal series; fillets several; e. f. *reddish, longitudinal striæ close, distinct,* central suture evident. L. 1-39″; B. 1-370″. (III. 40.) = *C. decussatum* (Kg.)? G.B., I., F., G., U.S.A.

C. *prælongum* (Bréb.). — Frond *very slender,* extremely long, thirty-five to forty times as long as broad, slightly curved, *very gradually tapering*; upper margin slightly convex, with a depression near each extremity; lower concave, inclined upwards towards the rounded ends; large granules in a single series; e. f. *colourless, without markings.* F.

C. *quadrangulare* (Corda). — Frond very slender, twenty-five to thirty times as long as broad, slightly curved, gradually tapering, *quadrangular,* except at the extremities, *one of the angles forming a prominent longitudinal median line*; upper margin equally convex, lower concave, very slightly inclined upwards at the blunt ends; e. f. colourless, smooth. G.

3 * *Frond tapering, the lower margin concave, often with a central inflation, and inclined downwards towards the rounded or subacute ends; e. f. without markings.*

† Frond slender, curvature very slight.

C. *strigosum* (Bréb.).—Frond slender, twelve or fifteen times as long as broad, *nearly straight, but somewhat curved downwards towards the attenuated extremities*: upper margin slightly convex, lower *concave with a gentle central inflation*; *ends acute*; large granules in a single series; e. f. colourless, without striæ. Sporangium orbicular, smooth, placed between the shortly deciduous empty fronds, which conjugate soon after division, so that two of the empty segments are considerably shorter than the other two. F.

C. *macilentum* (Bréb.). — Frond very slender, *sublinear,* twenty-five or thirty times as long as broad, slightly and very gradually curved, somewhat tapering; upper margin slightly convex, lower *slightly concave; ends somewhat blunt*; large granules, in a single series; e. f. colourless, without striæ. Sporangium orbicular, placed between the for some time persistent empty fronds, which conjugate, as in last, soon after division. F.

C. *gracile* (Bréb.). — Frond very slender, about twenty-five to thirty times as long as broad, *linear*, nearly straight, except at the extremities, *which are curved downwards*; sides parallel, ends obtuse; *endochrome arranged in a zigzag or subspiral manner*; e. f. *without striæ*. I., F. This species resembles *C. juncidum*, *a*, in form, but differs in the arrangement of the endochrome and in the absence of striæ.

2 † Frond crescent-shaped, curvature considerable.

C. *Ehrenbergii* (Menegh.). — Frond *large, stout*, about five or six times as long as broad, lunately curved, extremities tapering; upper margin very convex, lower concave *with a conspicuous central inflation*; ends broadly rounded; large granules, *numerous, scattered*; fillets several; e. f. colourless, without striæ, central suture not evident. Sporangia orbicular, smooth, placed between the but slightly connected empty conjugated fronds, the endochrome during the process of conjugation emerging from the opened apex of a short conical extension from each under side of each younger segment (or shorter cone) of each pair of recently divided fronds, the conjugating fronds being produced immediately previously by the self-division of a pair of old fronds—two sporangia being thus the ultimate produce of the two original fronds. L. 1-68″; B. 1-400″. (XVI. 10, 11, 12, 13, 14.) = *Lunulina monilifera* (Bory), *C. Lunula* (Ehr., Hass.). G.B., I., F., G., U.S.A.

C. *moniliferum* (Ehr.).—Frond *smaller than the last*, stout, five or six times as long as broad, lunately curved, extremities tapering, upper margin convex, lower concave *with a central inflation*, ends rounded; large granules, *conspicuous, in a single longitudinal series*; e. f. colourless, without striæ, suture not evident. L. 1-75″ to 1-60″; B. 1-510″ to 1-466″. G.B., I., F., G., Italy, U.S.A.

C. *obtusangulum* (Corda). — Frond stout, crescent-shaped, four or five times as long as broad, rapidly attenuated, "quadrangular" (six angles?); upper margin very convex, lower concave *without a central inflation; ends narrowly rounded*; e. f. colourless, without markings.

C. *Jenneri* (Ralfs).—Frond small, distance between the extremities six or seven times the breadth, crescent-shaped, much curved, *gradually* tapering (sometimes with an obscure central constriction); upper margin very convex, lower very concave without a central inflation; *ends obtuse, rounded*; large granules, in a single series; e. f. colourless, without striæ. L. 1-281″; B. 1-1730″. G.B., I., F., U.S.A.

C. *Leibleinii* (Kg.).—Frond somewhat stout, distance between the extremities six or eight times the breadth, crescent-shaped, much curved, *rapidly attenuated*; upper margin very convex, lower very concave, *often with a slight central inflation; ends subacute*; large granules, in a single series; fillets few or indistinct; e. f. somewhat straw-coloured, without striæ; suture evident. Sporangium orbicular. L. 1-291″ to 1-165″; B. 1-1632″ to 1-582″. (II. 1 & 5.) G.B., I., F., G., Italy, U.S.A. β more slender, scarcely inflated on the lower margin.

C. *Dianæ* (Ehr.). — Frond slender, crescent-shaped, six or eight times as long as broad, much curved, rapidly attenuated; upper margin very convex, lower very concave *without a central inflation; ends subacute with a very slight emargination at the upper outer extremity*; large granules, in a single series; e. f. somewhat straw-coloured or faintly reddish, without striæ, suture evident. L. 1-143″; B. 1-1275″. = *C. ruficeps* (Ehr.), *C. arcuatum* (Bréb.)?, *C. Venus* (Kg.)?, *C. acuminatum* (Kg.)?. G.B., I., F., G., Italy, U.S.A.

C. *incurvum* (Bréb.).—Frond minute, somewhat stout, crescent-shaped, very much curved, rapidly attenuated, ends very acute; e. f. without striæ. F.

4 * *Fronds gradually tapering, curvature often gradual, lower margin concave, inclined downwards at the rotundato-truncate or sometimes subacute ends; e. f. striated.*

C. *inæquale* (Ehr.). — Frond minute, semilunate, attenuated; upper margin very convex, lower concave; *extremities unequal*, conic, *very acute*; large granules, scattered; e. f. prominently striated. G.

C. *costatum* (Corda). — Frond stout, about five or six times as long as broad, lunately curved, attenuated; upper margin convex, equally arched, lower concave; *ends obtuse, rounded*; large granules, in a single series; e. f. *reddish, striæ few* (about six), *conspicuous*; suture evident. Sporangium orbicular, smooth, placed between the deciduous empty fronds. L. 1-75″; B. 1-384″. = *C. turgidulum* (Kg.). G.B., I., F., G.

C. *striolatum* (Ehr.).—Frond from six to ten times as long as broad, lunately curved, attenuated; upper margin convex, *slightly depressed at the centre*, lower concave; ends *very obtuse*, rounded; large granules, in a single series; e. f. *reddish*, especially near the ends, *striæ very numerous, crowded, transverse sutures usually three*. Sporangium orbicular, smooth, placed between the dehiscing deciduous empty fronds. L. 1-80″ to 1-68″; B. 1-625″ to 1-535″. (II. 2 & 6.) = *C. regulare* (Bréb.)?. G.B., I., F., G., Italy, U.S.A.

C. *intermedium* (Ralfs).—Frond slender, twelve to fifteen times as long as broad, slightly curved, *very gently tapering*; upper margin convex, *gradually arched*, lower slightly concave; ends obtuse, rounded; large granules, in a single series; e. f. pale straw-coloured, striæ *distinct, numerous, but not crowded*; transverse sutures usually more than three. L. 1-77″-1-54″; B. 1-1073″. G.B., I., F.

C. *angustatum* (Kg.).—Frond slender, ten to twenty times as long as broad, sublinear, slightly curved, *scarcely attenuated*; upper margin convex, gradually arched, lower concave; ends truncate, slightly rounded; large granules, in a single series; e. f. pale reddish, especially near the ends, *striæ few* (about four), *very distinct, transverse sutures usually three*. L. 1-60″; B. 1-1142″. G.B., I., F., G.

C. *juncidum* (Ralfs).—Frond very slender, from about fifteen to even thirty-five times as long as broad, *linear, straight except towards the extremities, which are somewhat curved downwards, ends obtuse*; e. f. nearly colourless, *striæ not numerous, faint, transverse sutures usually three*. Sporangium orbicular, smooth, placed between the dehiscing deciduous empty fronds. G.B., I., F. *β*, frond stouter, less elongated.

C. *uncinatum* (Kg.).—Frond slender, *tapering to a subacute point, suddenly curved downwards*; e. f., the *body with striæ fine and close, absent at the extremities*.

C. *lineatum* (Ehr.).—Frond slender, elongate, from about eighteen or twenty to twenty-five times as long as broad, gently curved, very gradually attenuated; upper margin unequally convex, *being most curved near the ends*, lower concave or somewhat protuberant at the centre; *sides somewhat parallel for a portion of their length; the extremities gradually tapering, slender, curved downwards, ends obtuse*; large granules, in a single series; e. f. reddish, *striæ numerous, distinct, one or more transverse lines at the central suture*. Sporangia double, rounded, smooth, in close approximation, their opposed surfaces flattened, placed between the dehiscing, shortly-deciduous empty fronds, and each formed by the mutual conjugation of the contents of the adjacent opposite segments. L. 1-48″; B. 1-909″. (III. 41, 42.) G.B., I., F., G., Mexico. *β*, striæ spiral; *γ*, striæ very faint, except at the centre of the frond (Bréb.).

C. *decorum* (Bréb.). — Frond about twelve to twenty times as long as broad, *tapering from the centre, gradually curved*; upper margin equally convex, lower margin concave; *extremities attenuated*, slender, obtuse; large granules, in a single series; e. f. *colourless*, striæ numerous. F.

5 * *Frond gradually curved, tapering, suddenly contracted at the end into a conical point.*

C. *attenuatum* (Ehr.).—Frond eight to twelve times as long as broad, gently curved, gradually attenuated; upper margin slightly convex, lower concave; *extremities suddenly contracted into an obtuse conical point*; large granules, in a single series; e. f. reddish, with numerous close striæ, central suture evident. L. 1-57″; B. 1-669″. (III. 43.) G.B., I., F., G.

6 * *Frond ventricose or narrow-lanceolate, rapidly tapering into a distinct beak.* (*Sporangia cruciform.*)

C. *Ralfsii* (Bréb.).—Frond stout, six to nine times as long as broad; the *upper margin slightly convex*, the *lower concave, but ventricose at the middle*; each extremity tapering into a narrow, slender, *reddish beak, shorter than the body*, slightly curved downwards, ends obtuse; large granules, conspicuous, in a single series; e. f. reddish, especially near the ends, striæ numerous, close, and distinct, *central suture accompanied by several transverse lines*. L. 1-79″; B. 1-526″. G.B., F.

C. *rostratum* (Ehr.). — Frond from about ten to fifteen times as long as broad, *lanceolate*; *upper and lower margins nearly equally convex*; each extremity tapering into a narrow, setaceous, nearly colourless beak, *nearly equal in length to the body*, curved downwards, ends obtuse; large granules, in a single series; e. f. colourless or somewhat straw-coloured, striæ numerous, close; *suture solitary*. Sporangium somewhat cruciform, its sides concave, its extensions truncate, attached to the empty conjugated fronds. (III. 44.) L. 1-69″; B. 1-680″. *C. cau-*

datum (Corda), *Stauroceras Acus* (Kg.). G.B., I., F., G., Italy.

C. *elegans* (Bréb.).—Frond very slender (twenty-five to thirty times as long as broad), *narrow-lanceolate*, upper and lower margins nearly equally convex, each extremity tapering into a long, slender, setaceous, colourless beak, *about as long as the body*, ultimately curved downwards, *ends acute*; large granules, in a single series; e. f. *without striæ*. F.

C. *setaceum* (Ehr.).—Frond very slender, from about twenty to twenty-five times as long as broad, *narrow-lanceolate; upper and lower margins nearly equally and but slightly convex*; each extremity tapering into a very long, slender, setaceous, colourless beak, *longer than the body, ultimately curved* downwards, *ends obtuse*; e. f. colourless, *striæ close, faint*, central suture *solitary*. Sporangium cruciform, similar to the last. L. 1-116″; B. 1-2381″. = *Stauroceras subulatum* (Kg.), *S. intermedium* (Kg.), *C. Kützingii* (Bréb.). G.B., I., F., G., Italy, U.S.A.

C. *pronum* (Bréb.).—Frond very slender (thirty to thirty-five times as long as broad), nearly straight; upper and lower margin *scarcely inflated*, nearly equally though *very slightly convex*; very gradually attenuated at each extremity into a long, slender, setaceous, colourless beak, ultimately somewhat curved downwards, ends *slightly enlarged and rounded*; e. f. colourless, *without striæ*. F.

7 * *Frond minute, tapering, curvature very slight, neither inflated nor rostrate.* (*Sporangia cruciform.*)

C. *Cornu* (Ehr.).—Frond minute, from five to eight times as long as broad, slender, slightly curved, attenuated, *ends blunt*; endochrome not reaching to the extremities; large granules, indistinct, in a single series; e. f. colourless, without striæ. Sporangium in f. v. somewhat cruciform or quadrate, with the angles produced and rounded, in s. v. elliptic, attached to the conjugating fronds. L. 1-140″; B. 1-3709″. = *C. tenue* (Kg.). G.B., F., I, G., Italy. *β*, frond more turgid. L. 1-226″; B. 1-2142″. G.B., I., F.

C. *acutum* (Bréb.),—Frond somewhat larger than the last, about from six to twenty times as long as broad, slender, narrow-lanceolate, slightly curved, gradually attenuated, *ends acute*; e. f. colourless, without striæ. Sporangium similar to last. L. 1-177″; B. 1-2550″. G.B., I., F., G. *α* six to twelve times as long as broad, ends subacute. *β* ten to twenty times as long as broad, ends very acute. = *Stauroceras subulatum* (Kg.)?, *C. subulatum* (Bréb.)?, *C. tenerrimum*, (Kg.)?

C. *Griffithii* (Berk.).—Frond minute, *scarcely curved, acicular*, very acute, smooth. = *C. subtile* (Bréb.)? G.B., I., F.

8 * *Frond crescent-shaped, stout, extremities furnished with a single acute spine.*

C. *cuspidatum* (Bailey).—Frond stout, *crescent-shaped*, scarcely tapering, much curved, *ends rounded, furnished with a single subulate acute spine*; e. f. without striæ. U.S.A. We are disposed to think this plant may not be a true Desmidiean, but belong to the genus Ophiocytium (Näg.), though placed in Closterium by Bailey.

Genus PENIUM (Bréb.).—Frond elongate, straight, cylindrical, elliptic, or lanceolate, *either not at all constricted or but very slightly narrowed at the middle, entire.* Endochrome with or without a terminal clear space, containing active granules.

* *Empty frond granulate, generally reddish.*

Penium *margaritaceum* (Bréb.). — Frond six to ten times as long as broad, fusiform or cylindrical, with rotundato-truncate ends, rough with pearly granules *arranged in longitudinal lines*. Endochrome at each end, sometimes with a more or less distinct terminal cavity with active granules. Sporangium orbicular, smooth. = *Closterium margaritaceum* (Ehr.). G.B., I., F., G. *α*, frond fusiform, gradually constricted at the middle, granules distinct. L. 1-156″; B. 1-961″. (II. 14.) *β*, frond linear, scarcely contracted at the middle, granules distinct. *γ*, frond linear, not contracted at the middle, granules appearing like puncta. L. 1-169″; B. 1-1515″. (II. 15.)

P. *Cylindrus* (Bréb.).—Frond minute, red, three or four times as long as broad, *cylindrical, not contracted at the middle, ends rotundato-truncate*, rough with minute, closely scattered, pearly granules; e. f. red. L. 1-492″; B. 1760″. = *Closterium Cylindrus* (Ehr.), *Dysphinctium Cylindrus* (Näg.). G.B., I., F., G.

P. *annulatum* (Näg. sp.).—Frond minute, *scarcely twice as long as broad, cylindrical or subelliptic, sides and ends broadly rounded*, rough with minute granules *arranged in transverse lines*, which give a minutely denticulate appearance to the margin, except at a very narrow central annular space, where they are absent, thus imparting a somewhat constricted appearance; e.v. circular, margin minutely granulate. = *Dysphinctium annulatum* (Näg.). I., G.

2 * *Empty frond smooth, colourless.*

P. *Digitus* (Bréb.).—Frond large, stout, smooth, three or four times as long as broad, *elliptic-oblong*, sides and ends broadly rounded; *endochrome in obscure and undulated fillets, interrupted only by the pale central transverse band*, and having no clear space at the extremities. L. 1-81″; B. 1-299″. = *Closterium Digitus* (Ehr.), *Penium oblongum* (De Bary)? G.B., I., F., G., U.S.A.

P. *lamellosum* (Bréb.).—Frond large, stout, smooth, about four times as long as broad, *gradually contracted at the middle*, and tapering to the extremities, ends somewhat truncate; *endochrome in obscure and undulated fillets*, in transverse view radiate, its rays divided, and having no clear space at the extremities. F., G.

P. *Nægelii* (Bréb. in litt.).—Frond large, stout, smooth, about four times longer than broad, oblong, *not contracted at the middle*, gradually tapering to each extremity, *sides nearly straight, ends broadly truncate*; endochrome arranged *in interrupted divided planes radiating from the central axis*, in f. v. being *indented somewhat in a pinnatifid manner*, the rays touching the cell wall, sometimes divided, and somewhat dilated thereat, in transverse view radiate. = *Closterium (Netrium) Digitus* (Näg.). I., G.

P. *interruptum* (Bréb.).—Frond large, stout, smooth, three or four times as long as broad, *cylindrical, sides parallel, extremities conical, and rounded* at the ends; endochrome disposed in *straight, strongly marked fillets, interrupted by three transverse pale bands*, having a rounded, well-defined clear space near the ends, in which are active granules. L. 1-116″; B. 1-571″. (III. 45.) G.B., I., F., G., U.S.A.

P. *closterioides* (Ralfs).—Frond *rather large*, about six times as long as broad, smooth, *fusiform or lanceolate, ends broadly rounded*; endochrome in distinct longitudinal fillets, interrupted only by the central transverse pale band, *with a single longitudinal series of large granules*, and a rounded clear space *close to the ends*, in which are active granules. L. 1-92″; B. 1-590″. G.B., I., F., U.S.A.

P. *Navicula* (Bréb.).—Frond *minute*, about three or four times as long as broad, smooth, *fusiform, ends bluntly pointed*; endochrome sometimes in fillets, sometimes scattered, interrupted only by the transverse central pale band, *with one or two large granules in each half*, and a rounded clear space *at the ends*, in which are active granules. L. 1-420″; B. 1-750″. = P. *Berginii* (Archer). I., F.

P. *truncatum* (Bréb.).—Frond minute, two to four times as long as broad, *cylindrical, smooth, ends truncate.* Sporangium orbicular, smooth, placed between the *dehiscing, deciduous empty fronds.* L. 1-969″ to 1-555″; B. 1-2212″ to 1-2100″. G.B., I., F.

Genus SPIROTÆNIA (Bréb.).—Frond elongate, *straight, cylindrical, or fusiform, entire*, not constricted at the middle, ends rounded or acute; *endochrome spiral.* (Gelatinous investment very apparent; cell-division oblique; fructification unknown, therefore the position of this genus uncertain.)

* *Endochrome a single spiral band.*

SPIROTÆNIA *condensata* (Bréb.).—Frond cylindrical, five to ten times as long as broad, ends rounded; endochrome a single, broad, *closely-wound spiral band, its revolutions numerous.* L. 1-208″; B. 1-1048″. (II. 4.) G.B., I., F., G., U.S.A.

S. *muscicola* (De Bary).—Frond cylindrical, two to four times as long as broad, ends rounded; endochrome a single, broad, smoothly-defined, *widely-wound spiral band, its revolutions very few* (one or two). L. 1-142‴ to 1-71‴; B. 1-287‴. = *Palmoglœa endospira* (Kg.), *Cylindrocystis endospira* et *Endospira truncorum* (Bréb., Kg.). F., G.

S. *erythrocephala* (Itzigsohn, Braun). Frond *fusiform*, five or six times as long as broad, ends *acute*; endochrome a single, *rather narrow* spiral band, its revolutions few. = *S. minuta* (Thuret, Bréb.). F., G.

2 * *Endochrome in several spiral bands.*

S. *obscura* (Ralfs).—Frond cylindrical or fusiform, five to eight times longer than broad, extremities attenuated, ends blunt; endochrome *in several slender spiral bands, their revolutions two or three,* sometimes scattered, leaving a clear space at each extremity, in which there is sometimes a free granule. L. 1-247″ to 1-226″; B. 1-1020″ to 1-907″. G.B., I., F.

C. *Cells stipitate.*

Genus COSMOCLADIUM (Bréb.). — Cells rounded, compressed, deeply constricted at the middle, stipitate.

COSMOCLADIUM *pulchellum* (Bréb.).—Stipes dendroid, dichotomously branched, hyaline, with a slight intermediate thickening between the cells; cells terminal and axillary, green, segments elliptico-reniform, smooth (III. 63). F.

We here provisionally place this remarkable plant, discovered by M. de Brébisson, not knowing as yet anything as to its mode of growth or development. The cells, if detached from the stipes, would scarcely be distinguishable from those of *Cosmarium bioculatum.*

D. *Cells aggregated into families, forming fasciculi or faggot-like bundles.*

Genus ANKISTRODESMUS (Corda).—Cells minute, smooth, elongated, attenuated, aggregated into families forming fasciculi or faggot-like bundles, each family resulting from the self-division of a single cell, which commences by the formation of a somewhat oblique septum at the middle, eventually rendered more and more oblique from the young cells growing alongside one another longitudinally until they each attain the length of the original parent-cell, the process being again and again repeated by each till the aggregated family consists of at most thirty-two cells, the family finally again breaking up into single cells. No other propagation known; the position of the genus is therefore doubtful.

ANKISTRODESMUS *falcatus* (Ralfs).—Cells very slender, arcuate (rarely straight or sigmoid), gradually attenuated, ends acute. L. 1-550″; B. 1-7353″. (I. 35, 36.) = *Rhaphidium fasciculatum* (Kg., Näg.). G.B., I., F., G., Italy.

A. *convolutus* (Corda). — Cells much curved, crescent-shaped, somewhat rapidly attenuated, ends subacute. = *Rhaphidium minutum* (Näg.). I., F., G. We have met with a plant (gathered near Dublin) which we now (though doubtfully) refer to this species, in which we noticed self-division of the cells, in an at first oblique, finally longitudinal manner, very much the same as that described by Nägeli (*Einzell. Alg.*) for the preceding species, and introduced into the generic character. The cells in our plant are not quite so much curved as in Nägeli's drawing of this species, and are rather more acute at the extremities: we have not noticed the fasciculi to be composed of more than 8 cells, frequently of 2 or 4; and while so combined the cells all look in the same direction, the concave surface of the one being applied to the convex surface of its neighbour.

A. *contortus* (Thuret).—Cells slender, arcuate or sigmoid, somewhat gently inflated at the centre, ends drawn out long and very fine. F.

[*Scenodesmus duplex* (Ralfs) is placed in this genus by Kützing and Nägeli under the name of Rhaphidium; that plant may, however, be the cell of an Ankistrodesmus undergoing division.]

Subfamily PEDIASTREÆ (page 24).

We shall not attempt to give anything but a very provisional diagnosis of the genera here included under the above title (which have long been associated with the Desmidiaceæ, and chiefly for that reason finding a place in the present work), as, so far as we can judge, it is not yet determined whether they should remain united with the Palmellaceæ, to which they have been referred by Nägeli, or, with some few other Algæ, form a distinct group near Palmellaceæ, and perhaps Volvocineæ. They cannot, we think, continue to be considered as belonging to the Desmidiaceæ. For the purposes of the present work, however, as they are introduced, we shall just indicate that the genera here described under the above head agree in the following characters:—

Cells combined into a definitely formed frond or family, often either externally notched or attenuated, sometimes spinous, not undergoing complete self-fission in the same direction into two perfect cells, but propagating by the repeated segmentation of the contents of the old cells into a definite number of portions or "gonidia," which are either still or for a time motile, and which are either arranged according to the typical plan within the parent-cell, and by its bursting set free as a new frond or family, or become so arranged without the parent-cell, but still involved in its inner membrane, the whole having emerged by a transverse fissure.

We are disposed to think that here Hydrodictyon should come; for though in this plant the development of the active gonidia is simultaneous, not successional, as in Pediastrium, Pringsheim alludes to the gonidia in *Cœlastrum sphæricum* (which indeed are still) as either the one or the other. *Crucigenia quadrata* (Morren)=*Staurogenia quadrata* (Kg.), seems to propagate by complete self-fission, and, gonidia not being described, we believe cannot belong here. As to Sphærodesmus (Näg.) information is wanting.

Genus SCENODESMUS (Meyen).—Frond or family composed of from two to eight oblong fusiform or elliptic cells, *connected into a single or double continuous row*; propagating by means of the repeated segmentation, in parallel planes in one or two directions, of each of the cell-contents into one or more brood families (not motile), set free by the bursting of the parent-cell wall. (Näg.)

SCENODESMUS *quadricauda* (Ralfs).—Cells in a single row; oblong, rounded at their ends; external cells (sometimes more turgid than the others) *furnished at each extremity with an elongate, often curved, acute spine or bristle*, sometimes with another from the centre of the outer margin. L. 1-1121″; B. 1-2631″. (I. 40, 4[illegible] 43.)=*Achnanthes quadricauda* (Turp.), *Arthrodesmus quadricaudatus* (Ehr.), *Scenedesmus caudatus* (Corda, Kg.), *S. quadricaudatus* (Hass.). G.B., I., F., G., U.S.A. *β*, central cells furnished at one of their ends with an elongate, acute, curved spine or bristle, each half of the frond being so furnished at opposite sides, sometimes the central cells being also furnished at their other ends with a very short, minute spine. =*S. Nägelii* (Bréb.). (I. 42.)

S. *dispar* (Bréb.).—Cells two or four, *alternating*, oblong, blunt at the ends; when four the central cells at one end at *opposite* sides of the frond furnished with a short acute mucro-like dejected spine, *each spine directed inwards*; when either two or four, the external cells with a similar spine at both ends; when four, that spine at the same side of the frond with that belonging to the central cells also directed inwards, *the other directed outwards*. F.

S. *antennatus* (Bréb.). — Cells in a single or double row; fusiform, or semilunate, ends *cuspidate, and each terminated by a minute orbicular globule*. F.

S. *dimorphus* (Kg.).—Cells in a single row; narrow, attenuated, and pointed at the ends; *the central in apposition the most of their length*, the outer externally lunate. L. 1-1020″ to 1-906″; B. 1-8160″. =*Achnanthes dimorpha* (Turp.), *S. pectinatus* (Meyen), *Arthrodesmus pectinatus* (Ehr.). G.B., I., F., G.

S. *acutus* (Meyen). — Cells in alternating rows; the central fusiform, *in apposition only at their middle*, the outer sometimes externally lunate. L. 1-1663″ to 1-1060″; B. 1-6250″ to 1-6181″. = *Arthrodesmus acutus* (Ehr.), *S. acutus* et *obliquus* (Ralfs). G.B., I., F., G., Italy.

S. *obtusus* (Meyen).—Cells in one or two rows, *all ovate or oblong*, ends rounded. L. 1-2331″ to 1-1961″; B. 1-4096″ to 1-3623″. (I. 37, 38, 39.) G.B., I., F., G., U.S.A.

S. *duplex* (Ralfs).—Cells two, slender, tapering, *sigmoid*, acute, *placed side by side for about half their length*. = *Rhaphidium duplex* (Kg.), nec *S. moniliformis* (*duplex*) (Kg.). G.B., G. This plant possibly represents a cell of an Ankistrodesmus during division.

Genus PEDIASTRUM (Meyen).—Frond or family plane, circular, elliptic, or irregular, composed of several cells (a multiple of four), forming by their union a *flattened star-like group*, generally arranged in more or less concentric circular series, marginal cells externally bipartite or entire; propagating by "macrogonidia," which are subglobose, formed by repeated binary division of the endochrome of each of the parent-cells of the old frond, 2, 4, 8, 16, 32, or 64 (even 128) in number, and making their exit by a transverse fissure from the parent-cell, involved in its inner membrane, within which for a time they actively move, presently settling down and arranging themselves into a new frond; "microgonidia" produced in the same manner, but shortly rupturing the confining membrane and swimming freely away, their fate unknown (Braun).

* *Lobes of the outer cells two, deeply emarginate or truncate.*

PEDIASTRUM *Tetras* (Ralfs).—Frond very minute; cells *four, their interstices forming a cross*, their outer margin bilobed, angles acute. L. 1-2941"; B. 1-2272". (II. 27.) = *Micrasterias Tetras* (Ehr.), *P. biradiatum* (*Tetras*) (Kg.). G.B., I., F., G., U.S.A.

P. *heptactis* (Menegh.).—Frond minute; cells eight (*seven disposed in a single series round a central one*), bilobed, angular. L. 1-2900"; B. 1-2500". = *Micrasterias heptactis* (Ehr.), *Euastrum hexagonum* (Corda), *P. simplex* (Hass.), *P. biradiatum* (*heptactis*) (Kg.). G.B., I., F., G., U.S.A.

P. *biradiatum* (Menegh.).—Inner cells subquadrilateral, with a *linear* notch, the outer quadrilateral or *somewhat cuneate, approximate for their entire length*, externally deeply bipartite, their incisions narrow, the subdivisions truncate or truncato-emarginate. L. 1-1200" to 1-2550"; B. 1-1754" to 1-2040". = *Micrasterias Rotula* (Ehr.), *P. biradiatum* (*Rotula*) (Kg.). This with the two preceding may possibly make but one true species, *P. Ehrenbergii* (Braun.). (I. 52.) G.B., I., F., G., U.S.A.

P. *Rotula* (Ehr. emend. Braun).—Inner cells with a *wide* notch, and separated by wide lacunæ, the outer subquadrilateral, *approximate only at their bases, which are nearly square*, externally deeply bipartite, their incisions broad, the subdivisions narrow, inciso-dentate. F., G.

P. *caudatum* (Braun).—Inner cells pentagonal or hexagonal, with a deep linear notch, the outer quadrangular, externally deeply bipartite, the subdivisions truncate, very *slightly concave at the centre, and furnished at the angles with a very minute, short, bristle-like spine*. = *P. Rotula* (Näg.). G.

2* *Lobes of the outer cells two, entire, attenuated.*

P. *Selenæa* (Kg.).—Cells *crescent-shaped*, arranged in one or more circles round one or two central ones, *connecting medium coloured*. = *P. elegans* (Hass.), *P. lunare* (Hass.). G.B., F., G.

P. *gracile* (Braun).—Frond minute, of four or six cells (four external, with or without two central cells); marginal cells deeply bipartite; subdivisions *ovate, tapering to a point*. L. 1-1020"; B. 1-1632". = *Micrasterias Coronula* (Ehr.), *P. Napoleonis* (Hass., Menegh., Kg., nec Ralfs), *P. simplex* (Ralfs). G.B., F., G.

P. *pertusum* (Kg.).—Cells arranged in circles round one or two central ones; inner cells quadrangular, sides concave and *leaving angular vacant intervals; the outer cells with square bases*, externally *triangularly notched*, the subdivisions tapering to an acute point. L. 1-2266"; B. 1-3268". = *Micrasterias Boryana* (Ehr.), *P. tricyclium* (Hass.), *P. emarginatum* (*pertusum*) (Kg.). G.B., I., F., G.

P. *granulatum* (Kg.).—Cells eight, *rough with minute granules*, six cells arranged round two central, the inner subquadrate, the outer having two tapering lobes. L. 1-2000"; B. 1-1850". G.B., I., F., G.

P. *Napoleonis* (Menegh.).—Cells eight, six arranged round two central, the inner variable, the outer having two cuspidate lobes, *the notch wide*. (I. 62.) L. 1-1570" to 1-1483"; B. 1-1813" to 1-1088". = *P. hexactis* (Hass.). G.B., G.

P. *Boryanum* (Menegh.). — Cells arranged in one or more circles round one or two central; the inner variable, generally concave at one side, the outer tapering into *two long subulate points, the notch narrow.* L. 1-2083″ to 1-1633″; B. 1-2733″ to 1-2222″. (I. 59, 60, 61, 68, 69, microgonidia.) = *Micrasterias Boryana* (Ehr.), *P. subuliferum* (Kg.), *P. cruciatum* (Kg.). G.B., I., F., G., U.S.A.

P. *ellipticum* (Hass.). — Cells varying in number and arrangement; outer cells *suddenly contracted into two short, cylindrical, obtuse processes.* L. 1-1754″ to 1-906″; B. 1-1515″ to 1-1020″. *β*, processes of the lobes truncato-emarginate. = *Micrasterias elliptica* (Ehr.), *P. vagum* (Kg.), *P. constrictum* (Hass., Kg.), *P. bidentulatum* (Braun). G.B., I., G., U.S.A.

P. *angulosum* (Menegh.). — Cells arranged in one or more circles round one central, the inner cells roundly angular, the outer *obliquely truncate, emarginate, the subdivisions not tapering into rays.* L. 1-2732″; B. 1-1942″. = *Micrasterias angulosa* (Ehr.). G.B., F., G.

3* *Outer cells with only one attenuated lobe* (Monactinus).

P. *simplex* (Meyen).—Cells *eight*, in a single series surrounding a central vacant interval, *narrow-ovate or lanceolate*, very gradually tapering, acuminate, approximate only at their bases. = *Monactinus simplex* (Kg.), *M. simplex* et *acutangulus* (Corda), *M. octonarius* (Bail.)? F., G., U.S.A. There seems to us to be some doubt as to the absolute distinctness of this and *P. gracile* (Braun), as it is possible the four deeply bipartite external cells of the latter may have been mistaken for eight simply attenuated cells as described for *P. simplex* (Meyen).

P. *duodenarium* (Bailey, sp.). — Inner cells *four*, somewhat triangular, enclosing a central, quadrate vacant interval, and four broadly lanceolate vacant intervals between them and the outer series, to which they are united by their terminal angles; outer cells twelve, subovate, *truncate below*, much attenuated, acuminate. = *Monactinus duodenarius* (Bail.). U.S.A.

P. *ovatum* (Braun).—Cells *ovate*, terminating in a long, acute point, *granulate*, arranged in two series, inner three, outer ten. = *Asterodictyon ovatum* (Ehr.), *Monactinus ovatus* (Kg.). G.

P. *Triangulum* (Braun).—Cells *triangular*, smooth, arranged in three series, the centre vacant. *Asterodictyon Triangulum* (Ehr.) = *Monactinus Triangulum* (Kg.). G.

4* *Outer cells not lobed* (Anomopedium).

P. *integrum* (Näg.).—Frond irregular, cells *rounded* or bluntly angular; outer cells *not emarginate*, generally possessing externally two short mucro-like spines (I. 46, 47, 48). G.

Genus CŒLASTRUM (Näg.).—Frond or family hollow, globular or subcubical, composed of polygonal (or spherical) cells *united in one layer into a hollow clathrate net-like family*, the cells drawn out on the exterior into one or more lobes, or simply spherical; propagating by the segmentation of the cell-contents into a definite number of portions which become arranged into a hollow young frond resembling the parent, ultimately set free by the bursting of the parent-cell.

CŒLASTRUM *sphæricum* (Näg.). — Fronds spherical or oval; cells hexagonal, drawn out externally into a blunt cone, interstices 5–6-angular. (I. 49, 50, 51.) G.

C. *cubicum* (Näg.).—Frond subcubical, cells hexagonal, drawn out externally into two short truncate projections, interstices quadrangular. (I. 54, 55.) G.

C. *microporus* (Näg.).—Frond globular, cells exactly spherical, interstices minute. G.

Genus SORASTRUM (Kg.).—Frond or family *solid*, globular, composed of cuneiform or cordate cells, somewhat compressed and *united into globular families, their narrow ends meeting in the centre* and outwardly emarginate or divided. Propagation unknown.

SORASTRUM *spinulosum* (Näg.).—External margins of the cells dilated, slightly emarginate, the rounded angles furnished each with two minute, acute, subulate spines. (I. 56, 57, 58.) G.

S. *echinatum* (Kg.). — External margins of the cells deeply bifid, the subdivisions subulate. G.

Sub-group DIATOMEÆ or DIATOMACEÆ.

(Page 31, Plates IV. to XVII. and part of II.)

[For reference to the species figured in this work, see Index of Diatomaceæ illustrated.]

Frustules or cells, either simple or pseudo-unicellular by complete separation, or united in tablets or filaments, furnished with a sculptured siliceous coat in three portions, a median one (connecting zone) and two lateral ones (valves) united by distinct sutures; internal substance yellowish-brown (rarely olive-brown); reproduction by conjugation and subsequent formation of sporangia.

The general history of the Diatomaceæ has been so fully treated of in the first part of this work (p. 31) that it is here only necessary to explain some terms used in the descriptions.

The Diatomaceæ differ, in several respects, so widely from acknowledged Algæ, that in our opinion they may be regarded rather as an order related to the Algæ than as a family belonging to them.

The siliceous covering is composed of three portions. The central one is sometimes called "connecting membrane" and "cingulum;" we, however, prefer Professor Arnott's term, "connecting zone," as less likely to mislead. The lateral or junction surfaces correspond to the septa of a Conferva, and are called valves.

The late Professor Smith considered the central portion unessential and produced only preparatory to self-fission. We, on the contrary, regard it as of great importance, and quite unknown in the true Algæ. It is conspicuous in the conjugating and, consequently, mature frustules; and we think the conclusion illogical that it has no systematic value because obscure in newly-formed frustules. It is evidently essential in Diatoms with flat valves, since otherwise there could be no cavity to contain internal matter.

We use the term "front view" to denote that position of the frustule when the connecting zone is fully presented to the eye, and "side view" when the centre of the valve is in a similar position. When we speak of the "valve," unaccompanied by a qualifying epithet, it must be understood as identical with "side view."

"Longitudinal" means in the direction of the connecting zone, and "transverse" in the opposite direction uniting the valves. When so applied to the frustule of a Diatom, these terms acquire a meaning exactly the reverse of that in which they are used when applied to the joint of a Conferva and the frond in the Desmidieæ. For example, the frustule in some Diatoms and the frond in Closterium are both described as longitudinally lunate, whilst they are really extended in opposite directions: unless the change in the meaning of the terms be remembered, an idea of similarity will be conveyed which is altogether erroneous.

The valves are sculptured, cellulose, or striated; the apparent absence of striæ in some instances may be accounted for by their extreme delicacy placing them beyond the reach of our instruments, since the greater the penetration of the object-glass, and the more perfect the illumination, the greater is the number of species found to possess them. When, therefore, we use the terms "smooth" and "very smooth" in definitions taken from foreign works, they must be understood to mean only that the striæ were too fine to be ascertained by the microscope of the describer.

The word "transverse" is, for the sake of brevity, omitted before striæ in the definitions, but, unless the contrary be expressed, it must always be understood.

When the frustules are lunate or curved, the convex margin is called the dorsum and the opposite the venter.

We have not mentioned the Sporangia in the generic and specific descriptions, because the examples recorded are too few, and that condition is too seldom met with to be practically useful. With respect to the general history of the Diatomaceæ, the importance of Mr. Thwaites's discoveries can scarcely be overrated (see p. 61). We consider it, however, desirable to point out, that whilst the similarity of their conjugating process to that of the Desmidieæ affords a powerful argument in support of the vegetable nature of the Diatomaceæ, the widely different characters of their sporangia, not merely in form but in subsequent changes, furnish irresistible evidence of the propriety of separating the Desmidieæ from the Diatomaceæ. The resemblance of the reproductive bodies in the latter to the parent frustules, and their continuous growth and increase by self-division, is so unlike what we find in the sporangia of the Desmidieæ and Conjugatæ, as to appear more like an "alternation of generations" than examples of true sporangia.

The first attempt at a scientific arrangement of the Diatomaceæ was by C. A. Agardh in the 'Conspectus Criticus Diatomacearum.' He distributed them into three families—Cymbelleæ, Styllarieæ, and Fragilarieæ, according to the form of their frustules. He considered that in each family the frustules might be free, stipitate, united into a filament, or enclosed in a frond. This system was greatly extended and improved by Professor Kützing; and, as we believe his arrangement (p. 101) is the best and most natural yet proposed, we have used it in this work, admitting, however, some judicious alterations proposed by Meneghini and others. It is true we do not meet with examples of the four conditions in each family; but they may fairly be anticipated to occur, and their absence regarded as lacunæ likely to be filled up by future discoveries. We have thus brought together nearly allied genera; for it is often difficult to distinguish a Eunotia from a Himantidium, a Triceratium from an Amphitetras, a Cymbella from a detached Cocconema, and an escaped frustule of Colletonema from a Navicula. The arrangements of Ehrenberg and Smith we regard as far inferior,—separating, as they do, such nearly allied forms. Indeed the fame of those eminent observers must depend on their intimate knowledge of genera and species, and on their definitions being superior to those of their predecessors, and not on their primary divisions. We feel persuaded that, but for his lamented death, Professor Smith would have been led by increased acquaintance with the Diatomaceæ to modify his views in that respect in a future edition of his valuable and beautiful work on the British Diatomaceæ.

ANALYSIS OF THE FAMILIES OF DIATOMACEÆ.

A.

1.	Valves with central nodule and median longitudinal line	B.
	" with umbilicus or pseudo-nodule and radiant lines or cellules	12
	" without a central nodule	2
2.	Frustules in side view lunate or arcuate	3
	" " with symmetrical margins	6
3.	Valves dissimilar	STRIATELLEÆ.
	" similar	4
4.	Valves cellulose, without transverse striæ	ANGULIFERÆ.
	" not cellulose	5

5.	Valves with pervious costæ or striæ	EUNOTIEÆ.	
	„ a longitudinal line or keel	SURIRELLEÆ.	
6.	Frustules cuneate in the front view		7
	„ not cuneate in the front view		11
7.	Frustules free; valves with alæ	SURIRELLA.	
	„ attached or united in filaments; valves without alæ ...		8
8.	Valves dotted, dots not forming striæ	EUCAMPIA.	
	„ not dotted, or the dots arranged in transverse lines		9
9.	Frustules radiating from a common centre; valves obovate or clavate		10
	„ not radiant; valves with symmetrical ends	FRAGILARIEÆ.	
10.	Frustules in front view with longitudinal vittæ	LICMOPHOREÆ.	
	„ „ without longitudinal vittæ (costæ pervious)	MERIDIEÆ.	
11.	Connecting zone (annulate) with imperfect internal septa	STRIATELLEÆ.	
	„ „ without internal septa		12
12.	Lateral view with 3, or more, angles or lobes	ANGULIFERÆ.	
	„ „ circular		17
	„ „ neither angular nor circular		13
13.	Valves not conspicuous in front view, which is mostly longer than broad		14
	„ compressed, inflated, conspicuous in front view, which is mostly broader than long		15
14.	Valves with a longitudinal line	SURIRELLEÆ.	
	„ without a longitudinal line	FRAGILARIEÆ.	
15.	Valves in front view, rectangular, with transverse capitate vittæ	TERPSINOËÆ.	
	„ „ with produced angles, processes, or spines		16
16.	Valves cellulose, symmetrical	BIDDULPHIEÆ.	
	„ not cellulose, mostly dissimilar	CHÆTOCEREÆ.	
17.	Frustules saddle-shaped; valves mostly with longitudinal blank space	CAMPYLODISCUS.	
	„ not saddle-shaped; central blank space (if any) orbicular		18
18.	Valves cellulose		19
	„ not cellulose	MELOSIREÆ.	
19.	Frustules simple; lateral view more conspicuous than front		20
	„ either united into filaments or front view broader than lateral	MELOSIREÆ.	
20.	Valves furnished with projecting processes	EUPODISCEÆ.	
	„ without processes, but sometimes with minute teeth	COSCINODISCEÆ.	

B.

21.	Only one valve with a central nodule		22
	Both valves with central nodules		23
22.	Frustules adnate, not genuflexed	COCCONEIDEÆ.	
	„ not adnate (often stipitate), genuflexed	ACHNANTHEÆ.	
23.	Frustules cuneate in front view; valves usually with dissimilar ends	GOMPHONEMEÆ.	
	„ not cuneate; valves with symmetrical ends		24
24.	Median line rib-like and distinct; nodules distinct		25
	„ not rib-like; nodules mostly obscure		2
25.	Side view lunate; nodule mostly excentric		26
	„ not lunate (rarely lunately curved); nodule central ...	NAVICULEÆ.	
26.	Valves ventricose, striæ not decussating	CYMBELLEÆ.	
	„ not ventricose, striæ decussating	TOXONIDEA.	

C.

Individuals of one piece, with radiating spines .... ACTINISCEÆ.

FAMILIES.

* *Valves without a central nodule.*

Eunotieæ. Meridieæ. Licmophoreæ. Fragilarieæ. Synedreæ. Surirelleæ. Striatelleæ. Terpsinoëæ. Biddulphieæ. Anguliferæ. Eupodisceæ. Coscinodisceæ. Melosireæ. Chætocereæ.

2* *Valves with a median line and a central nodule.*

Cocconeideæ. Achnantheæ. Cymbelleæ. Gomphonemeæ. Naviculeæ.

Actinisceæ.

FAMILY I.—EUNOTIEÆ.

Frustules free or adnate, in lateral view lunate or arcuate, with transverse striæ or costæ, not interrupted by a central nodule or longitudinal line. The essential characters of this group are the lunate form of the frustules in the lateral view, and the striæ being continuous across the valve, and not interrupted by a longitudinal line. It is easily distinguished, except from some species of Synedra, which, however, are linear-curved rather than lunate, and usually have an evident though faint longitudinal line. *Amphipleura inflexa*, which in form more nearly resembles Eunotia, has a longitudinal line passing down the middle of the lateral valves. The Eunotieæ have one surface of their connecting zone flat or concave and the opposite one convex, the convexity being usually greater than the concavity. The lateral portions or valves are either flat or convex; in the former case they do not appear in the front view, and the frustule appears quadrilateral; in the latter, on a front view, they have an oval form. Like most Diatomaceæ, the connecting zone has two puncta at each end.

Genus EPITHEMIA (K.).—Frustules lunately curved in lateral view, and furnished with transverse internal ribs (canals, Sm.); usually adnate by the flat or concave surface of the connecting zone, and not by one of the lateral valves, like Cocconeis. The lateral view has strongly-marked transverse lines, which Mr. Smith, in his beautiful work 'The British Diatomaceæ,' calls canaliculi. We consider them internal ribs; in fragments it is by no means difficult to see them, as they give a dentate appearance to the margin; their form is somewhat triangular, but we are unable to detect any internal cavity or canals. Mr. Smith, however, may have used microscopes of larger angular aperture and higher magnifying powers than we employed. Besides these ribs, the valves have transverse striæ or punctated lines. The adnate frustules and strongly-marked ribs distinguish Epithemia from Eunotia and Himantidium. In the front view the ends of the ribs frequently produce a beautiful beaded appearance. These beads form two longitudinal lines, and are more or less remote from the margins, according to the convexity of the lateral valves. They are frequently more numerous on one side than on the other, and are not all equidistant, even in the same series.

* *Front view gibbous at the centre, costæ fine.*

EPITHEMIA *gibba* (E., K.).—Front view elongated, linear, inflated at the centre and ends. KB. p. 33, t. 4. f. 22. = *Navicula gibba*, E Inf. p. 184; *Eunotia gibba*, EA & M, many figures. Fresh water. Common. Ehrenberg gives about 100 habitats in Europe, Asia, Australia, Africa, and America. (XII. 27.) Striæ 36 in ·001″; costæ 15 in ·001″.—Distinguished by its elongated frustules, fine striæ, and dilated ends; but, from its nearly straight side-view, its proper genus may be overlooked.

E. *ventricosa* (K.).—Front view elliptic, oblong, with gibbous middle; valves arcuate, with gibbous dorsum and attenuated, acute, somewhat incurved ends; striæ fine. KB. p. 35, t. 30. f. 9; SBD. i. pl. 1. f. 14. Fresh and brackish water. Europe.

E. *angulata* (Perty).—Dorsum turgid, sloping to the obtuse ends; venter concave at the centre, striæ about 12 in 1-1200″. Rab Diat. p. 18, t. 1. f. 18. = *Eunotia Jastrabensis*, EM. pl. 8. I. f. 3? Switzerland. Fossil. Hungary. According to the figures, the frustules are gibbous or rhomboid in the front view.

2* *Front view with marginal bead-like dots formed by the capitate ends of the costæ* (= Cystopleura, *Bréb.*).

E. *Argus* (E., K.). — Front view rectangular, with conspicuous ocelli terminating the stalk-like costæ, and having distinct striæ interposed between them. KB. p. 35, t. 29. f. 55. = *Eunotia Argus*, EA. p. 125, & M. t. 15 A. f. 59. Europe, Asia, Australia, and America. (xv. 11.) Valve lunately curved. Sporangial frustules with somewhat angular dorsum. A common species, easily recognized by the distinct marginal striæ interposed between the rather distant, conspicuous bead-like ocelli.

E. *alpestris* (K.).—Front view rectangular or subcuneate, with conspicuous marginal ocelli and interposed striæ; valves narrow, arcuate, with the rounded apices scarcely a little recurved. KB. p. 34, t. 5. f. 16. = *E. ostrantina*, Rab Diat. p. 19, t. 1. f. 29? France, England. (xiii. 8.) We are unable to distinguish this species from *E. Argus*; for we believe that the subcuneate front view is an accidental variation, and in specimens from M. de Brébisson we find that character by no means constant. Striæ are interposed between the ocelli, as in *E. Argus*, and are nearly, if not quite, as distant as in that species; and we doubt whether recurved extremities of the valves are not sometimes found in both.

E. *reticulata* (Näg.).—Front view rectangular, margins with stronger capitate and intermediate finer ones; valves slightly curved, the obtuse ends somewhat attenuated; striæ strong, 3 to 5 in 1-1200″; the interstices regularly reticulated, veined, margins finely transversely striated. KSA. p. 889. Switzerland.

E. *longicornis* (E., S.). — Front view subrectangular, with conspicuous marginal ocelli and striæ, as in *E. Argus*; valves elongated, curved, with obtuse ends and slightly angular dorsum. SBD. pl. 30. f. 247. = *Eunotia longicornis*, EM., several figures. Europe, Asia, and America. (xv. 6–9). Costæ strong, alternating with striated spaces. Perhaps a sporangial state of *E. Argus*.

E. *ocellata* (E., K.).—Front view barrel-shaped, with conspicuous marginal ocelli and interposed striæ; valves lunately curved, with rounded apices. KB. p. 34, t. 29. f. 57; SBD. pl. 1. f. 6. = *Eunotia ocellata*, E. Fresh water. Europe and America. Fossil. Greece.

E. *Eugeniæ* (S.).—Front view inflated, with truncate extremities; valves lunate, with straight, truncate extremities; costæ distinct, 8 in ·001″; ocelli conspicuous; striæ 32 in ·001″. S An. Jan. 1857, p. 7, pl. 1. f. 1. Fresh water. Biarritz, France. The nearest allies of this species are *E. proboscidea* and *E. Sorex*. It may be distinguished from the first by its distinct ocelli, and from the second by its conspicuous costæ and their areola-like interspaces. S.

E. *comta* (E.).—Small; valves curved, with regularly convex dorsum and rounded ends; striæ strong and granular. = *Eunotia comta*, EA. 1840, & M. pl. 6. 2. f. 17 *e, f*. Fossil. Greece. We are not certain whether this and the next species are correctly placed in the ocellated section.

E. *Hellenica* (E.). — Valves long, curved, with regularly convex dorsum and rounded ends; costæ strong, 4 in 1-1200″, having very delicate striæ intervening between them. = *Eunotia Hellenica*, EA. 1840, & M. pl. 6. 2. f. 17 *a, b*. Fossil. Greece.

3 * *Costæ not capitate.*

E. *constricta* (Bréb.). — Front view elliptical, slightly constricted at the middle; valve semilunate, with 8 distinct costæ in ·001″. SBD. vol. i. p. 14, pl. 30. f. 248. Brackish water. France and England. Striæ 30 in ·001″. S.

E. *margaritifera* (Rab.).—Front view barrel-shaped, with truncate ends and striated margins; valves with three dorsal undulations and rounded ends; costæ 4 to 5 in 1-1200″; bordered by puncta. Rab Diat. p. 17, pl. 1. f. 32. Persia.

E. *Musculus* (K.). — Front view suborbicular; valves lunate, with very convex dorsum, concave venter, and tapering acute apices; costæ distinct. KB. p. 33, t. 30. f. 6; SBD. pl. 1. f. 10. = *Eunotia Sphærula*, EM. pl. 8. 1. f. 6? Brackish water. Europe, Asia, Africa, and America. (xiii. 18.) Striæ 40 in ·001″. S.

E. *rupestris* (S.).—Front view elliptic or elliptic-lanceolate; valves semilanceolate, tapering to the subacute apices; costæ distinct; striæ faint, 40 in ·001″. SBD. vol. i. p. 14, pl. 1. f. 12. *E. gibberula*, KB. t. 30. f. 3; KA. p. 3. = *E. Westermanni*, SBD. vol. i. p. 14, pl. 1. f. 11. Fresh or brackish water. Europe and America.

E. *quinquecostata* (Rab.).—Valve semilanceolate, with obtuse ends, and five somewhat converging costæ. Rab Diat. p. 18, t. 1. f. 35. Germany.

E. *Hyndmani* (S.).—Front view ventricose with truncate ends; valves stout, lunately curved, with rounded apices; striæ moniliform, 16 in ·001″; costæ inconspicuous. SBD. vol. i. p. 12, pl. 1. f. 1. = *Eunotia Luna*, EM. pl. 15 A. f. 58. Britain. Large; valve not recurved.

E. *Westermanni* (E., K.).—Front view elliptic; valves semilunate, with turgid, convex dorsum gradually attenuated to the rather obtuse not prominent apices;

striæ scarcely converging, 7 or 8 in 1-1200″. KB. p. 23, t. 30. f. 4. = *Eunotia Westermanni*, E Inf. p. 190, & M, many figures. Europe, Asia, and America. (IV. 2; IX. 157.) In Ehrenberg's figures the frustules are large, the stout valves have the obtuse apices somewhat produced and recurved, and the interstices of the costæ furnished with dotted lines.

E. *gibberula* (E.).—Front view elliptic, with slightly produced apices; valves with gibbous dorsum, slightly concave venter, and attenuated, recurved apices; striæ converging, 33 in ·001″. = *Eunotia gibberula*, EA. p. 125, & M, numerous figures. = *E. Sorex*, KSA. p. 1; SBD. vol. i. p. 13, pl. 1. f. 9. Fresh or brackish water. Common. Europe, Asia, Australia, Africa, and America. Costæ inconspicuous.

E. *Saxonica* (K.).—Minute; front view rectangular; valves lunately curved, attenuated, with obtuse not recurved ends; striæ subconverging, 6 to 7 in 1-1200″. KB. p. 35, t. 5. f. 15. Italy and Germany. 1-840″.

E. *Textricula* (E., K.). —Valve linear, lunately curved, with rounded ends; costæ stout, distant; interspaces with series of longitudinal striæ. KB. p. 35, t. 29. f. 53. = *Eunotia Textricula*, EA. p. 126, & M, several figures. Europe, Asia, Australia, Africa, and America. Small; ends not recurved.

E. *Zebra* (E., K.). — Front view sublinear; valves semilunate, with convex dorsum, straight venter, and very obtuse, slightly prominent apices; costæ convergent, 5 to 7 in ·001″. KB. p. 34, t. 30. f. 5; SBD. pl. 1. f. 4. = *Eunotia Zebra*, E. Europe, Asia, Africa, and America. Striæ 33 in ·001″. S.

E. *zebrina* (E., K.).—Elongated; valves with evenly convex dorsum, gradually decurrent into the obtuse, constricted apices; interspaces dotted. KB. p. 34. = *Eunotia zebrina*, EA. p. 126, & M, several figures. Asia, Australia, America, and Europe.

E. *turgida* (E., K.).—Large; front view linear or slightly dilated at the middle; valves curved, with the slightly convex dorsum gradually attenuated to the truncate apices, which are neither prominent nor recurved; striæ diverging, 8 or 9 in 1-1200″. KB. p. 34, t. 5. f. 14. = *Eunotia turgida*, E Inf. t. 14. f. 5. Europe, Asia, and America. (IV. 1; IX. 159-161.)

E. *granulata* (E., K.). — Large; front view linear or linear-oblong; valves slender, slightly arcuate, with obtuse, recurved apices; striæ moniliform; costæ distinct. KB. p. 35, t. 5. f. 20. *E. Faba*, KB. p. 36, t. 5. f. 21. = *Eunotia granulata*, E Inf. p. 191, t. 21. f. 20 = *Epithemia turgida*, SBD. vol. i. pl. 1. f. 2. Europe, Asia, Africa, and America.

E. *Vertagus* (K.).—Large; front view sublinear, gradually dilated at the middle; valves slender, arcuate, with rounded, reflexed apices; costæ converging, 10 in 1-1200″; striæ punctate. KB. p. 36, t. 30. f. 2 = *E. granulata*, SBD. vol. i. t. 1. f. 3. Fresh water. Europe. Resembles the last, but the valves are far more slender.

E. *Librile* (E., K.).—Large; front view rectangular; valves arcuate, with concave venter, dorsum evenly convex at the middle, suddenly decreasing towards the obtuse, slightly revolute apices; interspaces between the costæ dotted. KB. p. 35, t. 29. f. 45. = *Eunotia Librile*, E Amer. p. 126, t. 3. 1. f. 38. Asia, Africa, and America. (XII. 24, 25.)

E. *Porcellus* (K.).—Large; front view linear, seven times as long as broad; valves with convex dorsum, concave venter, and truncate reflexed ends; striæ converging, 11 in 1-1200″. KB. p. 34, t. 5. f. 18, 19. Fossil. San Fiore. (XIII. 12.) 1-240″ to 1-216″.

E. *proboscidea* (K.). — Small; front view rectangular with obtuse angles; valves with gibbous dorsum, slightly concave venter, and constricted, obtuse, remarkably recurved ends; costæ conspicuous, converging. KB. p. 35, t. 5. f. 13; SBD. vol. i. p. 13, pl. 1. f. 8? Fossil, Lüneburg; Britain; recent, Jersey. Costæ 5 or 6 in 1-1200″. British specimens have the front view inflated, and therefore may be distinct.

E.? *marina* (Donkin). — Dorsal view rectangular, with longitudinal series of puncta on the connecting zone; valves linear, slightly arcuate, with produced rostrate apices; costæ conspicuous; interspaces punctated. Donkin, TMS. vol. vi. p. 29, pl. 3. f. 14. Marine. England. A large and beautiful Diatom, whose genus is somewhat uncertain. It agrees with Amphora in having the longitudinal rows of puncta confined to the dorsal surface, whilst in the form of its valves it resembles some species of Nitzschia. Costæ and striæ 11 in ·001″. Donkin.

Doubtful and insufficiently known species.

E. *Electra* = *Eunotia Electra*, EM. pl. 37. 3. f. 3. Fossil. Prussia. Valve semiorbicular, with strong, radiant striæ.

E. *Lindigii* (Rab.). — Minute; front view orbicular; costæ 6 to 7. Rab Diat. p. 19, pl. 1. f. 20. Bogota.

E. *Sancti Antonii* = *Eunotia Sancti Antonii*, EM. pl. 34. 5. f. 7, &c. America. Front view rectangular, with conspicuous marginal capitate striæ; valves obtusely lanceolate, straight, with strong transverse costæ. Probably a Denticula.

E. *Beatorum* = *Eunotia Beatorum*, EM. pl. 34. 5. f. 8. America. Front view rectangular, with marginal gland-like puncta. According to Ehrenberg, this species is allied to *E. Sancti Antonii*.

E. *Lunula* = *Eunotia Lunula*, EM. pl. 33. 7. f. 9, & pl. 33. 14. f. 8. Ehrenberg's figures differ considerably. The first is slightly arcuate, elongated, with obtuse, slightly recurved ends; the second is smaller, lunate, rapidly tapering to the obtuse ends. Both have radiant costæ without intermediate dotted lines.

E. *mesolepta* = *Eunotia mesolepta*, EM. pl. 9. 1. f. 26. Fossil. France. Valves elongated, slightly curved, with attenuated middle, and conic ends; costæ alternating with dotted striæ.

E. *mesogongyla* = *Eunotia mesogongyla*, EM. pl. 9. 1. f. 27. Fossil. France. Valves linear, elongated, slightly curved, with gibbous middle, and rounded ends; costæ alternating with dotted striæ.

E.? *Faba* (E., K.).—Valves semioval, slightly arcuate, with obtuse, very slightly recurved apices, and 9 moniliform striæ in 1-1200″. = *Eunotia Faba*, EM. Several figures. Ehrenberg's figure seems to us rather to represent a Eunotia than an Epithemia.

E.? *cingulata* (E., K.).—Small, smooth, with convex dorsum and tumid connecting zone. KB. p. 36. = *Eunotia? cingulata*, EA. p. 126, t. 2. 6. f. 34. North America. Akin to *E. gibberula*, E.

E. *Cocconema* = *Eunotia Cocconema*, EM. pl. 34. 7. f. 1. Canton. Valve stout, semilunate, with regularly convex dorsum, straight venter and rounded ends, strong costæ, fine intermediate striæ, and a longitudinal blank line.

E. *Cistula* = *Eunotia Cistula*, EM. pl. 8. 1. f. 5, &c. Asia. Front view oblong or elliptic, with costate margins; valves stout, lunate, with obtuse ends, strong, radiating costæ, and a blank longitudinal line.

Genus EUNOTIA (E.). — Frustules free, in front view quadrangular, in lateral view lunate, or arcuate, and striated. In form, Eunotia is allied to Epithemia; but the lateral surfaces of the frustules are merely striated, and want the conspicuous costæ of that genus. The superior margin is usually undulated,—an appearance caused by transverse depressions. The frustules are not adnate, and in the front view do not appear beaked.

We believe that the species in this genus, as in several others, have been founded upon insufficient characters, and that those forms which differ only in the undulations should, as Professor Bailey suggests, be regarded as varieties. As this work, however, is intended to include all generally admitted species, we are content to indicate our opinion, the correctness of which must be determined by future observations. Kützing and Meneghini describe the transverse section as trapezoidal, and regard it as an important generic character; but we agree with Professor Smith in doubting the occurrence of such a form. Several species of Eunotia have been found by Bailey and Brébisson united into short bands; and unless the generic characters of Eunotia and Himantidium can be strengthened, it will become necessary to reunite these genera. The dorsal elevations in Eunotia and Himantidium appear, in the front view, transverse darker bands.

* *Dorsal margin of valves not dentate.*

EUNOTIA *nodosa* (E.).—Valves slightly arcuate, with inflated centre and reflexed obtuse apices. ERBA. 1840, p. 15, & M. pl. 15 B. 3. f. 25. Asia and America. Lough Mourne deposit.

E. *Formica* (E.).—Valves linear, with inflated centre and ends. EA. p. 126, & M. pl. 3. 4. f. 18. Australia and America. Akin to *E. nodosa*, but with inflated and straight apices. E.

E. *ventralis* (E.). — Valves elongated, linear, curved, with tumid, rounded apices, and gibbous venter. EA. p. 126, & M, several figures. Europe, Asia, Africa, and America.

E. *Luna* (E.).—Valves linear, lunately curved, with simply convex dorsum, gibbous venter, and obtuse apices.

ERBA. 1845, p. 77, & M. pl. 33. 12. f. 13. Fossil. Oregon.

E. *Sina* (E.).—Valves linear, slightly curved, with rather concave venter; dorsum suddenly sloping down to the produced, acute, reflexed apices. ER BA. 1845, p. 77, & M. pl. 33. 12. f. 16. Fossil. Oregon.

E. *biceps* (E.).—Valves linear, curved, with dilated, slightly revolute, broadly rounded ends. EA. p. 125, & M. pl. 5. 2. f. 36. Europe and America. Some at least of Ehrenberg's figures in the 'Microgeologie' belong to *Synedra flexuosa*.

E. *Alpina* (K.) = *Himantidium Halcyonellæ* (Perty). — Valves with turgid convex dorsum, slightly produced subtruncate apices, and very fine transverse striæ. KB. p. 36, t. 3. f. 10. Switzerland.

E. *incisa* (Greg.). — Valves arcuate, slender, with obtuse or subacute apices, and subterminal notches or depressions on the ventral margin; striæ fine, 44 in ·001". Greg MJ. vol. ii. p. 96, pl. 4. f. 4. Lapland, Scotland.

E. *Plectrum*, EM. pl. 6. 2. f. 15. Fossil. Sweden. Valve semilunate, constricted beneath the capitate apices; venter straight; dorsum evenly convex.

E. *Hemicyclus* (E.). — Small; valves linear, curved, semicircular, with obtuse apices and distinct transverse striæ. = *Synedra Hemicyclus*, ERBA. 1840, & M. t. 16. = *E. Falx*, Greg MT. vol. ii. p. 105; MJ. vol. iii. pl. 4. f. 1. Fossil. Sweden.

2* *Valves with two dorsal and three ventral undulations.*

E. *Crocodilus* (E.).—Valves elongated, slightly curved, with two dorsal and three ventral undulations; apices produced, subacute, reflexed. ERBA. 1845, p. 77; M. pl. 34. 5 A. f. 4. Africa and America.

E. *Tapacumaë*, EM. pl. 34. 5 A. f. 5. America. Valve with two dorsal and three ventral undulations separated by deep sinuses; apices abruptly produced into a short beak. *E. Tapacumaë* seems to differ from *E. Crocodilus* in its stouter form, deeper sinuses, and more abruptly produced apices.

3* *Valves with dentate or crenate dorsum.*

E. *Camelus* (E.). — Valves striated, small; dorsum with two approximate rounded elevations, sloping to the attenuated, produced, obtuse apices. EA. p. 125, t. 2. 1. f. 1. Asia, Africa, and America.

E. *bidentula* (S.).—Valves faintly striated, with two prominent, acute or rounded dorsal ridges, very straight ventral margin, and obtuse, produced apices. SBD. vol. ii. p. 83. *E. Camelus*, Grev ANH. 2nd series, vol. xv. pl. 9. f. 1. Britain. Differs from *E. Camelus* in its straight ventral margin.

E. *Sella* (E.).—Valve dilated; ventral margin straight; dorsum with two central ridges, from which it passes with a regular convexity to the acute apices. EA. p. 126, t. 2. 1. f. 7. America.

E. *Zygodon* (E.).—Valves linear; dorsum with two approximate ridges, from which it passes by a curvature to the rounded apices. EA. p. 127, t. 2. 1. f. 6. America.

E. *declivis* (E.). — Valves with plane venter; dorsum convex, with two ridges which slope to the acute apices. EA. p. 125, t. 2. 1. f. 3. America.

E. *impressa*, EM. pl. 2. 2. f. 30, &c. America. Small, striated; valves narrow, linear, with two slight dorsal undulations and obtuse ends. Perhaps a bicrenate state of *E. tridentula*.

E. *bactriana*, EM. pl. 16. 1. figs. 29, 30, & pl. 16. 2. f. 19. Fossil. Sweden. This seems a distinct species, with linear, nearly straight valves, and two remote, minute dorsal teeth.

E. *diodon* (E.). — Valves stout, with two rounded dorsal ridges and broadly rounded ends; striæ distinct, radiant. E Inf. p. 192, t. 21. f. 23; SBD. pl. 2. f. 17. Recent and fossil. Europe, Asia, Africa, and America.—This and the thirteen following species of Ehrenberg we regard as mere varieties, which differ only in the number of their dorsal elevations. The species may be called *E. robusta*: its valves are stout, semilunate, with concave venter, broadly rounded ends, turgid convex dorsum furnished with conspicuous, rounded, diverging ridges, and the striæ are strongly marked and highly radiant; as, however, the valves increase in length, according to the increased number of dorsal ridges each is comparatively more slender than its predecessor, and the ridges are smaller and resemble crenations.

E. *triodon* (E.). — Has three dorsal ridges; otherwise resembles *E. diodon*. E Inf. p. 192; SBD. pl. 2. f. 18. Recent and fossil. Europe, Asia, Africa, and America. (IV. 4; IX. 164.)

E. tetraodon, E., Sm., K., Rab.; *E. pentodon*, E., K.; *E. Diadema* (6 crenations), E., K., Sm.; *E. heptodon*, E., K.; *E. octodon*, E., K.; *E. ennaodon*, E., K.; *E. decaodon*, E., K.; *E. hendecaodon*, E., K.; *E. dodecaodon*, E., K.; *E. serrulata* (13 crenations), E., K.; *E. prionotis* (14 crenations), E., K.; *E. polyodon* (all forms with more than 20 crenations), E., K. Fossil and recent. Europe and America.—Bréb., Rab., and Kütz. place *E. tetraodon* in Himantidium because the frustules are occasionally united into short tablets. We are unable to concur with them.

E. *Elephas* (E.).—Valves stout, curved, with three dorsal teeth and broadly rounded ends. EA. p. 126, t. 1. 4. f. 5. Brazil.

E. dizyga (E.). — Valves striated (?), semilunate; dorsum with four teeth, approximate at the middle. EA. p. 126, t. 2. 1. f. 8. Cayenne.

E. *Corona* (Rab.).—Valves nearly as broad as long; dorsum turgid, with five ridges; venter shorter, and separated from dorsum by a constriction. Rab Diat. p. 17, t. 1. f. 36. Italy. Striæ distinct, radiant.

E. *tridentula* (E.). — Small; valves finely striated, curved, narrow-linear, with *three slight dorsal crenations*, and obtuse recurved apices. EA. p. 126, t. 2. 1. f. 14; Grev Annals, 2nd series, xv. pl. 9. f. 2. Europe, Asia, Africa, and America.—We would unite this with the following thirteen species under the name of *E. Ehrenbergii*. The valves are linear, curved, with small dorsal teeth or crenations, and become larger and longer in proportion to the number of their teeth. The striæ are less radiant than in *E. robusta*, and the dorsum less turgid.

E. quaternaria, EA.; *E. quinaria* (XII. 39), EA.; *E. senaria*, *E. septena*, EA. = *E. septenaria*, EM.; *E. octonaria*, *E. nonaria*, *E. denaria*, *E. undenaria*, *E. Terra* (12 crenations), *E. tridenaria*, *E. quatuordenaria*, *E. quindenaria*, *E. bioctonaria*. Recent and fossil. Europe, Asia, Africa, and America. Ehr., Kütz.

E. *scalaris* (E., K.).—Dorsum with 17 dorsal teeth. EM. pl. 17. 1. f. 44. Fossil. Finland. In this and the two following species Ehrenberg probably included forms belonging to *E. robusta* and *E. Ehrenbergii*.

E. *icosodon* (E., K.).—Valves striated, linear, curved, with 20 dorsal teeth. ERBA. 1845, p. 77; Microg. pl. 33. 10. f. 3. Fossil. America.

E. *polyodon* (E.) resembles *E. icosodon*, but has more than 20 dorsal teeth. E. *l. c.* p. 77; Microg. pl. 17. 1. f. 45. Fossil. Finland.

Doubtful and insufficiently known Species.

E. *triglyphis* (E.) = *E. triodon*, Ralfs, Annals, vol. xiii. pl. 14. f. 3? Africa and America. Sussex?

E. *tetraglyphis* (E.). Asia, Africa, and America.

E. *pentaglyphis*, EM. pl. 16. 2. f. 22, & pl. 17. 1. f. 32. Europe, Asia, and America. Valves minute, linear, with five dorsal, approximate teeth. (IV. 3.)

E. *hexaglyphis*, EM. pl. 16. 1. f. 34, & pl. 16. 2. f. 24. Europe and Asia. Resembles *E. pentaglyphis*, but has six dorsal teeth.

The above forms are probably only varieties. They seem to differ from *E. Ehrenbergii* in more minute size, obsolete or indistinct striæ, and approximate teeth.

E. *Amphidicranon* (E.). — Valve quadrangular, straight, transversely striated, with constricted middle and emarginate ends. ERBA. 1845, p. 77; Microg. t. 33. 12. f. 14. Fossil. Oregon.

E. *brevicornis* (E.). — Oblong, dilated with suddenly acutely rostrate ends; venter slightly concave at the middle; dorsum slightly convex, nearly smooth (very finely striated?). ERBA. 1845, p. 363. Marine. India. = *A. Nitzschia*?

E. *Cretæ* (E.).—Valves striated, narrow-lanceolate, acute, very gradually attenuated at each end. ERBA. 1844, p. 81; EM. pl. 22. f. 55, 56. *Cocconema Cretæ*, E. Fossil. Sicily.

E. *Pileus* (E.).—Small, striated, subquadrate; venter wider than dorsum, the latter slightly furrowed; ends obtuse, rather prolonged. EM. pl. 39. 3. f. 42. Siberia, Africa, and America.

E. *Gangetica*, EM. pl. 35 A. 9. f. 2. India. Fragments large, striated, with straight venter, convex dorsum, and broadly truncate apices, which are slightly produced dorsally.

E. Australis; *E. cælata*; *E. Cygnus*; *E. Paradoxa*; *E. serpentina*, Australia, Ehr.; *E. Phrygia*; *E. lepida*; *E. Mosis*; *E. rostrata*; *E. Uralensis*; *E. apiculata*; *E. Siberica*; *E. borealis*; *E. Leptostoma*; *E. umbilicata*, Asia, Ehr.; *E. subulis*; *E. curva*; *E. carinata*, Africa, Ehr.; *E. Araucaniæ*; *E. edulis*, America, Ehr.; *E. Januarii*, Brazil, Ehr.; *E. Guianensis*; *E. Demeraræ*; *E. Pomeroni*; *E. Surannæ*; *E. synedra*, Guiana, Ehr.; *E. Columbi*, Columbia, Ehr.

Genus AMPHICAMPA (E.).—Frustules in lateral view lunately curved, having pervious transverse striæ and denticulated margins. Amphicampa is closely allied to Eunotia and Himantidium, but differs in having teeth on both margins.

AMPHICAMPA *mirabilis* (E.).—Valves linear, with rounded ends; dorsum with six or seven teeth, and venter with five. EM. pl. 33. 7. f. 2. = *A. Eruca*, EM. pl. 33. 7. f. 1. Mexico. (IV. 5.)

Genus HIMANTIDIUM (E.).—Frustules united into filaments or tables; lateral view arcuate or lunate, transversely striated. If all the species in Himantidium formed ribbon-like filaments, there would be no difficulty in distinguishing it from Eunotia; but this is not the case, and Kützing has well said, "It must be noticed that in many species of Himantidium the individuals are not always united into a band, and therefore the generic character is very variable and stands on a weak foundation." Professor Smith observes that "there is no mark to distinguish the valves of the two genera unless it be in the character of the striæ, which in Eunotia are radiate and in Himantidium parallel." If the striæ were indeed always radiate in the one genus and parallel in the other, a valuable diagnostic mark would be furnished; but, unfortunately, the convergent striæ occur only in those species of Eunotia which have a strongly convex upper margin. In the front view Himantidium resembles the Fragilarieæ, but in that family the lateral view is not arcuate.

* *Dorsum simple.*

HIMANTIDIUM *pectinale* (Dillwyn, K.).—Frustules united in long filaments; valves linear, arcuate, with flattened dorsum suddenly sloping to the obtuse apices, and slightly concave venter; striæ 27 in ·001″. KB. t. 16; SBD. p. 12, pl. 32. f. 280. = *H. minus*, KB. p. 39, t. 16. f. 10; *H. strictum*, Rab Diat. t. 1. f. 1 c; *Fragilaria pectinalis*, Lyngb.; *Fragilaria grandis*, E Inf. in part; *Eunotia depressa*, EA. p. 126. Europe, Asia, Africa, and America. (IV. 6.)

H. *Soleirolii* (K.).—Valves lunate, with evenly convex dorsum, concave venter, and rounded ends; striæ 30 in ·001″. KB. p. 39, t. 16. f. 9; SBD. vol. ii. p. 13, pl. 33. f. 282. = *Himantidium Faba*, EM. t. 1. 2. f. 3; *Eunotia Faba*, E. in part? Europe and Africa. (XIV. 13.) It might have been preferable to have adopted Ehrenberg's name for this species, since it is evident that the *H. Soleirolii* of Kützing was intended to include all forms with internal siliceous cells, and his figures of the valves belong to another species.

H. *parallelum* (E.).—Valves linear, strongly striated, curved, with simply rounded ends. EM. pl. 14. f. 58. = *Eunotia parallela*, EA. p. 126. Europe, Asia, Africa, and America.

H. *monodon* (E.).—Frustules large, few together; valves arcuate, with somewhat gibbous dorsum, and obtuse, slightly produced apices; striæ 34 in ·001″. EA. p. 129, t. 4. = *Eunotia monodon*, EM, many figures. SBD. vol. i. pl. 2. f. 16. Common. Europe, Asia, Australia, Africa, and America. (XV. 16, 17.)

H. *præruptum* (E.).—Valves striated, elongated; dorsum very convex, with a notch-like depression near the dilated truncated apices. = *Eunotia prærupta*, EA. p. 126, & M, several figures. Asia, Australia, and America. According to Ehrenberg's figures, its valves scarcely differ from those of *H. monodon*, except by their more truncate apices, and can scarcely be placed in another genus.

H. *Arcus* (E.).—Valves linear, arcuate; dorsum sinuated towards the rounded dilated apices. ERBA. 1840, p. 17, & M, many figures. = *Eunotia Arcus*, EM. Europe, Asia, Australia, Africa, and America. *β*, extremities gradually tapering, = *H. attenuatum*, Rab Diat. p. 19, t. 1. f. 10. Germany.

H. *gracile* (E.).—Valves slender, narrow-linear, slightly arcuate, with obtuse, somewhat recurved extremities. EA. p. 129, t. 2; SBD. vol. ii. p. 14, pl. 33. f. 285. = *Eunotia uncinata*, EA. p. 126, & M. pl. 15 B. f. 23. Europe, Asia, Australia, Africa, and America. Habit of *H. Argus*, but more slender, E. Striæ 27 in ·001″, S.

H. *majus* (S.).—Valves linear, arcuate, with rounded, subcapitate extremities: striæ 27 in ·001″. SBD. vol. ii. p. 14, pl. 33. f. 286. Britain. Differs little from *H. gracile*, save in its greater size and elevated dorsum, and is probably a sporangial form of it or some other species, S. It scarcely differs from some of Ehrenberg's figures of *H. parallelum*, except in its more inflated ends.

H. *exiguum* (Bréb.).—Valves slender, narrow-linear, arcuate, with obtuse recurved extremities, and 42 very delicate striæ in ·001″. KSA. p. 8. *Eunotia gracilis*, SBD. vol. i. p. 16, pl. 30. f. 249. Europe.

H. *Veneris* (K.). — Valves smooth, plano-convex, with acute apices. KB. p. 39, t. 30. f. 7. *Eunotia lævis*, EM. pl. 39. 3. f. 41. Trinidad.

2* *Valves with crenate or toothed dorsum.*

H. *bidens* (E.).—Valves with plane or slightly concave venter, biundulated dorsum, and dilated, truncate apices. EA. p. 9, & M, several figures. = *Eunotia bidens*, EA. p. 125, & M. pl. 2. 1. f. 2; *Eunotia bigibba*, KSA. p. 6? Europe, Asia, and America. The dorsum has a notch-like depression near each end.

H. *Guianense* (E.).—Valves dilated at the middle, with two dorsal undulations, and tapering, slightly reflexed ends. EA. p. 129, t. 2. 1. f. 4. Cayenne. (XII. 54.)

H. *Papilio* (E.).—Valves subquadrate, with a much dilated bicrenate dorsum, constricted near the obtuse apices. EA. p. 129, t. 2. 1. f. 2. Asia and America. (XII. 45, 49–52.)

H. *undulatum* (S.). — Valves linear, with gibbous venter, three or more slight dorsal undulations, and obtuse, somewhat recurved apices. SBD. vol. ii. p. 12, pl. 33. f. 281. Europe. Distinguished from the other British species by its gibbous venter.

H. *denticulatum* (Bréb.).—Valves very narrow, arcuate, with denticulated dorsum and slightly recurved apices. KSA. p. 10. France. Dorsum margined with minute teeth, constricted near the rounded apices.

H. *triodon* (Perty). —Valves smooth, with concave venter, convex triundulated dorsum, and broadly rounded ends. Perty, Inf. p. 198, t. 17. f. 5. Switzerland. Very like *Eunotia diodon*; but striæ have never been observed. Frustules mostly clear as crystal. Perty.

H. *ternarium*, EM. pl. 34. 6 A. f. 5. Florida. Valves arcuate, with slightly concave venter, three dorsal undulations, and obtuse apices.

H. *quaternarium* (E.). — Valves narrow, very finely striated; dorsum a little convex, deeply four-toothed; venter slightly concave, with attenuated and recurved apices. ERBA. 1852, p. 235. California. Joints of the chain 4 to 7, three times as broad as long, E.

H. *quinarium* (E.).—Valves as in *H. quaternarium*, but with five dorsal teeth. E. *l. c.* p. 535. California, Asia, and Africa. Joints of the chain 14, five times as broad as long. The frustules of *H. quaternarium* and *H. quinarium* are very similar to those of *Eunotia quaternaria* and *E. quinaria*, but are distinguished by forming chains and by the attenuated ends of the valves, E.

Doubtful Species.

H. *carinatum*, EM. pl. 34. 6 A. f. 6. Florida. Frustules rectangular, smooth, with a transverse median band.

H.? *marinum* (S.). — Filaments tenacious; valves costate, slightly and regularly arcuate, with acute apices; costæ 10 in ·001″. S Annals, Jan. 1857, p. 10, pl. 2. f. 14. Marine. France. Distinguished by its marine habitat and costate valves.

Species known to us only by name; probably several of them are merely concatenated states of Eunotia *and* Epithemia.

H. Australiæ, E., Australia; *H. Camelus*, E., Asia; *H. Textricula*, E., Asia; *H. Zebra*, E., Asia; *H. ventrale*, E., Asia; *H. amphioxys*, E., Asia; *H. umbilicatum*, E., Asia; *H. Æthiopicum*, E., Asia; *H. Falklandii*, E., Falkland Islands.

FAMILY II.—MERIDIEÆ.

Frustules prismatic, attenuated at the base, attached, at least when young, to a gelatinous cushion; in front view cuneate, in lateral view clavate or obovate, with pervious transverse costæ or striæ. Kützing places the Meridieæ between the Eunotieæ and Fragilarieæ; and Meneghini would unite them with the latter, for he "does not consider the cuneate form of the frustules of any value in an organological point of view," because of the occasional occurrences of such frustules in Diatoma and other genera of the Fragilarieæ. In the latter family, however, the cuneate frustules, when present, are in general interposed between those of the normal shape, and the lateral surfaces have not dissimilar extremities. Kützing observes that "the forms of this family have very great similarity to those of Gomphonema, with which they may be the more easily confounded when the individuals occur singly; but they are essentially distinguished from that genus by not having a central nodule in the secondary sides, and by their uninterrupted transverse striæ. Moreover, this family is much more closely united to the genus Odontidium, from which it is distinguished solely by the form of the secondary sides, which are not symmetrical at both ends." We, however, consider its affinity with the Licmophoreæ still more evident. The Meridieæ, Licmophoreæ, and Gomphonemeæ "form a group [the Styllarieæ of Agardh] distinguished by the triangular form of the frustules, which have their smaller ends directed towards a common centre. The frustules in this group have a central and two lateral portions, as in Diatoma and Fragilaria, in which genera cuneate frustules are also occasionally met with. But in the Fragilarieæ, when two or more cuneate frustules are united, the alternate frustules have their smaller ends in opposite directions, and hence their filaments are linear; whilst they are attached, if at all, only by the basal frustule. In this group, on the contrary, as the smaller ends are in the same direction, they point to a common centre, and when stipitate, each frustule is attached to the stipes" (Ralfs). The frustules in the Meridieæ have two puncta at the broader end, and sometimes other two, but more obscure, at the smaller end; they want, however, the sutural or fracture-like longitudinal lines which are present in the Licmophoreæ.

Genus MERIDION (Leibl., Ag.).—Frustules cuneate, united in a spiral filament; transverse costæ of lateral surfaces pervious. "The species vary according to the circumstances of development, as well with respect to size as to other relations. The individuals are met with both singly among other Algæ and also in masses. At times examples are found which are always composed of only few individuals; others again consist of individuals united in greater number; but generally the longer spiral ribands are rare." (Kütz.) Professor Kützing formed a new genus (Eumeridion) for the reception of *M. constrictum*; but his reasons have been considered inadmissible by De Brébisson, Meneghini, and Smith. Meridion is remarkable for the frequent occurrence within its frustules of an obovate silicious cell, which is usually, but not invariably, divided into two symmetrical portions by a longitudinal suture; the lateral margins of the inner cell, as well as the sutural line, are crenulate like those of the original frustule. The different aspect presented by specimens in this condition has induced some observers to describe them as a distinct species. Whilst we agree with Professor Smith that the modification is insufficient to warrant such a separation, we cannot coincide with him in regarding it even as a variety, since frustules with these internal cells are indiscriminately mixed with ordinary frustules in the same filament. So common, indeed, is this occurrence, prior to the termination of individual life, that we have long been convinced that it is the normal mode of termination in this genus.

MERIDION *circulare* (Grev., Ag.). — Frustules in lateral view clavate or obovate. SBD. vol. ii. p. 6, pl. 33. f. 277. =*M. vernale*, E.; *M. Zinckeni* (with internal cells), KB.; *B. curvatum*, K. Frustules slightly arcuate. Common, forming a mucous brown stratum on leaves, stones, &c., in shallow waters. β, France. (IX. 177, 178; XIII. 21, *M. Zinckeni.*) In both the primary and internal cells the lateral margins have a beaded appearance, produced by the ends of the lateral costæ.

M. *constrictum* (Ralfs).—Lateral valves constricted beneath the apex, otherwise as in *M. circulare*, SBD. vol. ii. pl. 32. f. 278. = *Eumeridion constrictum*, KSA. p. 11. Common. Europe. Internal cells as in *M. circulare*. We have received very perfect specimens from Mr. Okeden, gathered in Wales.

Doubtful Species.

M. ? *panduriforme* (E.). — Lateral valves constricted near the ends, the capitate extremity acuminated. E Infus. pl. 16. f. 3. 1-430″. Form that of *Gomphonema acuminatum*.

M. ? *ovatum* (Ag.). — Frustules ovate, combined into a cellulose lamina. KSA. p. 10. Sweden.

M. ? *coccocampyla*, EM. pl. 14. f. 79. Berlin. Perhaps a bad figure of one of the preceding species with internal cells.

M. *marinum* (Greg.). — Front view sublinear, with coarse marginal puncta; valves clavate, with 16 coarse marginal striæ in ·001″, and a blank longitudinal median line. Greg D Clyde, p. 25, pl. 2. f. 41. Marine. Scotland. Frustules two to four together. Certainly not a true species of this genus, as its costæ are not pervious.

Genus ONCOSPHENIA (E.).—Frustules quadrangular, cuneate, not concatenate; valves without an umbilicus, and also destitute of lateral apertures; and internal septa equal, but their apices unequal on account of their cuneate and uncinate form. Oncospheniæ approach nearest to Podospheniæ by the absence of pedicels in the latter, but are peculiar in their uncinate form. We are unacquainted with this genus, and ignorant of the reasons which induced Professor Kützing to place it among the Meridieæ.

ONCOSPHENIA *Carpathica* (E.).—Lateral valves cuneate, laxly striated; one end turgid, rounded, straight, the other attenuated and uncinate. KSA. p. 11. Carpathian Mountains. 1-792″: pinnules 11. Probably a distorted state of some other species similar to the variety of *Diatoma elongatum* figured by Professor Smith in BD. pl. 60. f. 311.

FAMILY III.—LICMOPHOREÆ.

Frustules cuneate, longitudinally bivittate, attached or stipitate, solitary or united in a fan-like manner; lateral surfaces striated or smooth, but not costate. The frustules in the front view are cuneate, and have, like the generality of the Diatomaceæ, two puncta at each end, the upper ones, however, being most conspicuous. Most frequently two longitudinal suture-like lines, corresponding to the puncta, are more strongly marked in the Licmophoreæ than in most other families; these Kützing calls "vittæ," and has formed a tribe which from them he calls "Diatomeæ vittatæ." The vittæ, however, are not peculiar to this tribe; for, as Meneghini justly remarks, "they are merely the same longitudinal lines which run along the primary surfaces of almost all the Diatomaceæ" (MeD. p. 462). Professor Smith describes them as "modifications in the outline of the valve, which in Podosphenia is slightly inflected at its larger extremity, causing, on a front view, the appearance of notches at the spot where the valves unite with the connecting membrane (central portion) and the foramina exist. The apparent prolongation of this notch to the lower extremity of the frustule is nothing more than the valvular suture which is seen in all the Diatomaceæ" (SBD. vol. i. p. 82).

The cuneate shape of the frustules in the front view, and the dissimilar ends of the lateral surfaces, distinguish the Licmophoreæ from Synedra, the species of which often resemble them in habit.

Genus PODOSPHENIA (E.).—Frustules affixed, in front view cuneate, in lateral view clavate, stipes none or obsolete. Podosphenia is identical with Styllaria (Ag.). Its sessile frustules distinguish it from the rest of the Licmophoreæ, and the absence of transverse costæ from the Meridieæ. "This genus represents in the Licmophoreæ the genus Sphenella of the Gomphonemeæ; for, like that, it is distinguished from other genera of the same family by the more or less complete absence of the stipes. The obovate-lanceolate figure of the secondary surfaces is precisely that of the Sphenellæ and of the Gomphonemeæ in general. The cuneate form of the primary surfaces is, in Podosphenia, always more dilated at the summit and acute at the base, so that they resemble a triangle more than a trapezium." (M *l. c.* p. 462.)

PODOSPHENIA *gracilis* (E.).—Frustules narrow cuneate, elongated, with somewhat acute base; lateral view clavate, smooth or with very obscure striæ. KB. t. 9. f. 10. 1. Europe. (x. 186.) β. *minor* 1-250″ to 1-110″.

P. *tenuis* (K.).—Linear cuneate, elongated, very slender, with acute base; lateral view narrow-clavate. KB. t. 30. f. 51. Norway.

P. *nana* (E.).—Small, smooth, narrow linear cuneate; lateral view clavate without lines. EM. pl. 11. f. 18, 19. Fossil. Bilin, Bohemia. 1-2300″ to 1-1720″.

P. *debilis* (K.). — Smooth, narrowly cuneate, rather acute at the base, subflabellate. KB. t. 8. f. 7. Europe. 1-1380″.

P. *tergestina* (K.). — Cuneate triangular, geminate or ternate, conjoined in a flabellate manner, base rather acute. KB. t. 8. f. 13. Trieste. 1-1440″.

P. *hyalina* (K.). — Very hyaline, cuneate, with approximate vittæ and subacute base; lateral view obovate pyriform. KB. t. 10. f. 2. β. *racemosa*, K., obsoletely stipitate, t. 10. f. 3. Europe. 1-570″ to 1-480″.

P. *cuneata* (Lyngb., Ag.). — Broadly cuneate with rather acute base; lateral view clavate or obovate, with obscure striæ. = *Styllaria cuneata*, Ag.; *Podosphenia abbreviata*, E.; *P. Lingbyei*, SBD. Europe. (XIII. 13 *b.*) 1-240″. Striæ 46 in ·001″, S. Broader and shorter than *P. gracilis*.

P. *Jurgensii* (Ag., K.). — Broadly cuneate with truncate base; lateral view clavate, with obscure striæ. SBD. i. p. 83, pl. 25. f. 228. Europe. 1-432″. Striæ 48 in ·001″, S.

P. *ovata* (S.).—Cuneate with rounded angles; lateral view obovate, tapering into an acute base; striæ moniliform. SBD. i. p. 83, pl. 24. f. 226. Shoreham harbour. Striæ 24 in ·001″. ·0033″ to ·0042″, S.

P. *Ehrenbergii* (K.). — Large, broadly cuneate; lateral view tapering at both ends and with distinct moniliform transverse striæ. SBD. pl. 24. f. 225. Europe. (IV. 7; XIII. 14.) 1-140″. Striæ 27 in ·001″, S.

Doubtful Species.

P. *Pupula*, EM. Several figures. Ehrenberg's figures have a clavate lateral valve with pervious transverse costæ and with or without a constriction. All probably belong to *Meridion circulare* and *M. constrictum*. He gives about twenty stations for this species in different parts of the globe,—none marine.

Genus RHIPIDOPHORA (K.).—Frustules stipitate, in front view cuneate, in lateral view obovato-lanceolate ("with a median longitudinal line," S.). "We encounter the same difficulty in distinguishing Rhipidophora from Podosphenia that is experienced when practically applying the generic distinction established between Sphenella and Gomphonema and in all other similar cases (Cymbella and Cocconema, &c.); these differ only in the stipes, which is very variable in length and not always entirely wanting in the first of these two genera.

"The large size of some among the species enumerated by Kützing permits us to observe clearly the conformation of the shield. Let us suppose a cylindrical articulation of Melosira, and so compress it unequally on one of its sides, and in the direction of both pairs of opposite surfaces, that the resulting form shall be cuneate, and the two incomplete diaphragms formed by the internal prominence of the longitudinal canals shall extend like these and lose themselves towards the pointed extremity which forms the base; such is the structure of Podosphenia and Rhipidophora. Viewed on one side, that is, on the lateral surfaces, they present an obovate arch, marked on the periphery of the surfaces themselves. The margin of this arch is thickened by the presence of the canal, which, seen in front, presents in the curve its brightness with an appearance of perforation." (Meneg *l.c.* p. 463.) Professor Smith says that "a close examination of the frustules shows us that the distinct and even moniliform striæ so conspicuous in Podosphenia are almost wholly wanting in our native species of Rhipidophora." The striæ in the former genus, however, are not always detected with facility, since Meneghini remarks that "of the nine species described and figured by Kützing, only one (*P. Ehrenbergii*) presents transverse striæ on the secondary surfaces." Careful observation of the species of Rhipidophora in a growing state will probably prove that several of them have been constituted upon insufficient grounds. It is to be feared, indeed, that characters taken from the comparative length and stoutness of the stipes, its simple and branched condition, and even the shorter or longer form of the wedge-shaped frustules in the front view, are more or less fallacious. We believe that at least some of the species are at first furnished with a short, thick, simple stipes, bearing the associated frustules at its apex, and that by the process of growth the frustules become longer in proportion to their breadth, and lose their flabellate arrangement by the subsequent elongation and dichotomous division of the stipes.

Rhipidophora *crystallina* (K.). — Shortly stalked, flabellate; frustules shortly cuneate, rather broad, obtuse at the base. KB. t. 9. f. 10. 5. German Sea. 1-1200″ to 1-1300″

R. *Œdipus* (K.).—Very shortly stalked, subflabellate; frustules oblong cuneate, truncate at the base; stipes hemispherical. KB. t. 18. f. 5. 5, 7. Europe. 1-600″ to 1-480″.

R. *Anglica* (K.). — Shortly stalked, flabellate; frustules turgid, cuneate with truncate base and obtuse terminal angles; stipes rather long, simple, thick. KB. t. 27. f. 5. 2, 4. Europe. 1-600″.

R. *Australis* (K.). — Flabellate; frustules narrowly cuneate with truncate base; stipes simple, thick. KB. t. 9. f. 5. Trieste. 1-540″.

R. *borealis* (K.). — Flabellate; frustules large, oblong cuneate with slightly obtuse base; stipes simple, rather stout. KB. t. 9. f. 6. Heligoland. 1-310″.

R. *Nubecula* (K.).—Frustules hyaline, broadly cuneate, somewhat acute at the base, scattered, subsolitary or fasciculate, lateral and terminal; stipes filiform, elongated, subramose. KB. t. 8. f. 16. Europe. (XIII. 17.) 1-720″ to 1-600″.

R. *tenella* (K.). — Minute; frustules small, broadly cuneate, conjoined in an imperfectly flabellate manner, acute at the base; stipes slender, very finely branched. KB. t. 11. f. 3. Europe. (XIII. 15.) 1-1080″ to 1-960″.

R. *Dalmatica* (K.). — Flabellate in a radiating manner; frustules oblong cuneate; stipes short, rather stout, at length subramose, tubular. KB. t. 9. f. 7. Europe. 1-540″. Lateral view narrow-clavate with very obscure striæ.

R. *abbreviata* (Ag., K.). — Subflabellate; frustules broadly cuneate with acute base; stipes rather thick, at length branched. KB. t. 9. f. 14 = *Licmophora abbreviata*, Ag. Europe. 1-540″. "Resembles *R. paradoxa*, but is distinguished by its green colour when dried." (Ag.)

R. *paradoxa* (Lyngb., K.).—Frustules short; broadly cuneate, somewhat acute at the base; stipes slender, filiform, dichotomous; lateral view clavate. SBD. i. p. 84, pl. 25. f. 231 = *Gomphonema paradoxum*, Ag. 1-540″ to 1-480″. Colouring matter dull olive. The frustule, especially in dried specimens, often has its angles so much rounded as to become obovate, — a character, however, not peculiar to this species. (IV. 8.)

R. *tincta* (Ag.).—Frustules elongated, narrow cuneate, with somewhat acute base; stipes elongated, subdichotomous, slender. = *Gom. tinctum*, A Consp D. p. 35; *R. elongata*, KB. t. 10. f. 6. 1-310″. Colouring matter dull olive. According to Agardh, it differs from *R. paradoxa* in its greener colour and longer and more slender frustules. He also states that it resembles smaller states of *Licmophora flabellata*, but is shorter and more lax, and without radiant frustules.

R. *oceanica* (K.). — Frustules oblong cuneate, dense; stipes elongated, slender, subdichotomous. KB. t. 10. f. 4. Atlantic. β flabellate. 1-390″. Internal matter fulvous.

R. *superba* (K.).—Frustules geminate or solitary, oblong cuneate, slightly acute at their base; stipes long, filiform, dichotomous, secondary branches lateral, short. KB. t. 10. f. 7. Europe. 1-310″. Elegant, slender, large; internal matter golden-yellow, globose, broadly distributed.

R. *grandis* (K.). — Frustules broadly cuneate, large; stipes very long, filiform, dichotomous. KB. t. 11. f. 1. β. *arachnoidea* (K.).—Frustules caducous, mostly lateral. Venice. Large, its internal matter granular, globose, olive. 1-120″.

R. *Meneghiniana* (K.).—Large; frustules geminate, oblong cuneate, with rather broad apices; stipes much elongated, filiform, dichotomous. KB. t. 11. f. 2. Venice. (XIII. 19.) 1-288″. Internal matter scattered, globose, olive-brown.

R. *Craticula* (Mont.).—Shortly stalked, subflabellate, dilated at the base, craticuliform; frustules two to six, lanceolate or oblong-lanceolate, with truncate apex, and obtuse, scarcely attenuated base. Montagne, A d Sci Nat. 1850, p. 308. Cayenne. 1-650″ to 1-450″. Stipes slender.

Genus LICMOPHORA (A.). — Frustules flabelliform, stipitate, in front view narrow-cuneate, laterally clavate; stipes thick, irregularly branched. Licmophora is nearly identical with Echinella of Ehrenberg. "The frustules of the present genus differ in no essential respect from those of Rhipidophora. They are, it is true, longer and narrower, and probably less firmly silicious; but none of these circumstances seem to be of generic importance. The separation of the genera must therefore rest upon the fan-like arrangement of the frustules upon the summit of an incrassate and irregularly dichotomous pedicel which occurs in Licmophora." (S *l. c.* vol. i. p. 85.)

Meneghini, however, says that "the resemblance of this to the preceding genus is only apparent. But a true affinity connects Licmophora to Synedra, from which it differs only in its cuneate frustules. . . . . The vittæ in Licmophora are not to be compared with those in Rhipidophora. They are nothing more than the usual longitudinal canals projecting into the cavity, by which the apparent perforations or sections of their cavities appear very near the margin of the summit. The distribution of the internal coloured substance is different from that in the two preceding genera, and greatly resembles that of Synedra." (M *l. c.* p. 464.)

LICMOPHORA *splendida* (Grev.). — "Frustules nearly linear, frequently attenuate and rounded at the upper extremity; in lateral view attenuate towards the upper end." SB. i. p. 85, pl. 32. f. 233. = *L. flabellata*, K.; *Echinella splendida*, E. Europe. Differs from the next species by its longer and narrower frustules, many of which are scattered and lateral.

L. *flabellata* (Grev., Ag.). — Frustules cuneate, truncate; in lateral view very narrow clavate. S. pl. 32. f. 233. = *L. radians*, K.; *L. argentescens*, Ag.; *Echinella flabellata*, E. Common. (IV. 9.; X. 191–193.)

"I have given, in accordance with the authority of my predecessors, two species of this genus; but I am far from satisfied that they are truly distinct, and I am disposed to believe that a wider comparison of specimens will necessitate their union." (SB. i. p. 85.) Being unable to determine the synonyms of Agardh, Ehrenberg, and Kützing, we have thought it better to follow Professor Smith than to risk increasing the confusion which exists. The *Licmophora argentescens*, Ag., is remarkable for its silvery lustre when dried; but we cannot detect any valid diagnostic difference. Both species are remarkable for the large and beautiful fan-like clusters of frustules terminating their branches; other frustules are lateral and scattered.

L. *Meneghiniana* (K.). — Frustules slender, very long, linear cuneate, terminal ones radiant, lateral ones scattered; stipes elongated, subdivided. KSA. p. 113. Adriatic Sea. Length of frustule 1-84" to 1-72". The characters given are insufficient to distinguish this species from *L. splendida*.

L. *divisa* (K.). — Frustules elongate cuneate, subsolitary or geminate (not flabellate), acute at the base; stipes short, weak, subdivided. KSA. p. 114. Adriatic Sea. (XIII. 16.) Length of frustule 1-240" to 1-180".

Genus CLIMACOSPHENIA (Ehr.). — Frustules in front view cuneate, with moniliform longitudinal vittæ, laterally obovate-lanceolate, divided into chambers by transverse septa. Marine. This genera resembles Podosphenia, except in having the peculiar transverse septa. "The two (first) species contained in this genus have nothing in common except the moniliform vittæ. But in what these really consist we cannot ascertain from the figures. In the first Kützing does not delineate the lateral surfaces, and from the figure any one would say that he had drawn a Synedra. The second, again, resembles a Podosphenia." (Meneg *l. c.* p. 465.)

CLIMACOSPHENIA *Australis* (K.). — Very shortly stalked, with smooth margins. KB. t. 10. f. 8. On Algæ. New Holland and Southern Africa.

C. *moniligera* (E.).—Frustules transversely striated on the margin; septa 10 to 11 in number. KB. t. 29. f. 80. Cuba, Mexico. (XI. 45, 46.)

C. *elongata* (B.).—Lateral view elongated clavate, the intercostal spaces with obsolete transverse striæ; stipes long, branched. BC. 1853, p. 8, pl. 1. f. 10, 11. Florida. Professor Bailey relies on the "elongated-clavate form of the frustules and their excessively minute striations, to distinguish this species from those previously described by Ehrenberg and Kützing. The striæ can be made out without much difficulty near the edges; but to trace them completely across the middle regions of the valve requires excellent lenses and careful management of the light." (Bailey.) Frustules in fan-shaped groups, narrow, linear-cuneate, with conspicuous moniliform longitudinal vittæ.

Genus PODOCYSTIS (K. & Bail.)=EUPHYLLODIUM (Sh.).—Frustules stipitate, cuneate in front view with obscure vittæ; valves with transverse costæ, moniliform striæ, and longitudinal median line. Podocystis differs from Surirella not only in its stipitate frustules, but in its moniliform striæ and absence of alæ; and from Rhaphoneis by its cuneate frustules. We have placed it with the Licmophoreæ because of its resemblance to Podosphenia, notwithstanding its obscure vittæ and strong transverse costæ. Marine.

PODOCYSTIS *Adriatica* (K.).—Valves ovate, with 11 or 12 striæ in 1-1200", stipes very short. =*Surirella* (*Podocystis*) *Adriatica*, KB. p. 62, t. 7. f. 8; *P. Americana*, BMO. pl. 11. f. 38; SD. ii. p. 101; *Euphyllodium spathulatum*, Shadb. MT. ii. p. 11, pl. 4. f. 4; *Doryphora? elegans*, Roper, MJ. ii. p. 284. f. 3. Europe, Africa, and America. (IV. 10.)

Genus SCEPTRONEIS (E.).—Frustules simple, affixed, cuneate, compressed, styliform; in the lateral view with moniliform transverse striæ, interrupted by a median longitudinal suture. Marine. Sceptroneis has the habit of a nonconcatenate Meridion and of a Gomphonema without the central nodule of the lateral valves.

SCEPTRONEIS *Caduceus* (E.).—Frustules bacillar, long, slender, inflated at centre and upper end, and tapering below. BAJ. xlviii. pl. 4. f. 11. Fossil, America; recent, Scotland. The lateral view, the only one we have seen, is narrow, somewhat clavate, constricted beneath the head, which is rounded at its apex. Transverse striæ with pear-like granules. Length 1-92", exceeding the width about 18 times. Professor Gregory gathered a fragment of this species in Scotland. (IV. 11.)

FAMILY IV.—FRAGILARIEÆ.

Frustules straight, free, or affixed by one angle of the basal frustules, in front view linear, in lateral view compressed, and striated or smooth, with a central nodule; striæ or costæ pervious. "The members of this family are allied in the genus Denticula to Surirella and Navicula; in the genera Odontidium and Fragilaria to Himantidium, Diadesmis, and the Meridieæ, and in Diatoma to Grammatophora and Tabellaria." (Kützing.) "The character by which these genera are collected together into one family is the conformity of the two primary surfaces; nor do I know how the genus Meridion is excluded even by the minutest characters." Kützing, indeed, "cites the affinities with Himantidium among Eunotieæ, with Diadesmis among the Naviculæ, and with the various genera of Striatelleæ. The relation appears to us rather one of analogy than of affinity, being the polypariform association of many individuals." (Meneghini.) Under Meridieæ we state the reasons which induce us to dissent from Meneghini's opinion respecting the position of Meridion. The striæ and costæ are usually continuous across the valve; and, indeed, Kützing makes their perviousness a distinctive character, separating the Fragilarieæ from the Surirelleæ. We regard Meridion as far more nearly allied to some genera belonging to the latter family than to the genera mentioned by Meneghini.

Genus DENTICULA (K.). — Free, solitary, or binately conjoined, rarely more; valves with pervious costæ, which appear in front view like marginal puncta. Fresh water. Denticula differs from Odontidium in not forming a filament, and also, according to Professor Smith, in having conspicuous striæ, which are wanting or obscure in Odontidium, and from Fragilaria by its strongly marked costæ, which Kützing regards as always pervious.

DENTICULA *tenuis* (K.).—Front view linear with punctated margin; valves narrow lanceolate, with 10 or 11 transverse costæ in 1-1200″. KB. p. 43, t. 17. f. 8. Europe. 1-1080″.

D. *frigida* (K.). — Front view linear, with finely striated margins; valves linear lanceolate, with 11 or 12 costæ in 1-1200″. KB. p. 43, t. 17. f. 7. Europe. Smaller than *D. tenuis*. 1-1200″.

D. *thermalis* (K.).—Front view oblong or trapezoid, with beautifully punctated margins; valves lanceolate, with 7 or 8 costæ in 1-1200″. KB. p. 43, t. 17. f. 6. Italy. 1-600″.

D. *elegans* (K.). — Front view linear oblong, with obtuse angles and gland-like marginal puncta; valves lanceolate, with 6 costæ in 1-1200″. KB. p. 43, t. 17. f. 5. Germany. (III. 4.) 1-660″.

D. *obtusa* (K.). — Front view linear, with striated margins; valves lanceolate, with obtuse ends, and 11 costæ in 1-1200″. KB. p. 43, t. 17. f. 14; SBD. i. p. 19, pl. 34. f. 292. Europe. 1-336″.

D. *crassula* (Nägeli). — Front view oblong, with punctated margins; valves elliptic, with 12 to 13 fine striæ in 1-1200″. Näg. in KSA. p. 889. = *D. inflata*, SBD. ii. p. 20, pl. 34. f. 294. Europe.

D. *acuta* (Rab.). — Front view mostly cuneate; valves slender lanceolate, with 6 or 7 costæ in 1-1200″. Rab Diat. p. 33, t. 1. f. 8. Persia.

D. *lauta* (Bail.). — Front view linear, with gland-like marginal puncta; valves linear lanceolate, with obtuse ends and distant costæ, which terminate in marginal bead-like dots. BMO. p. 9, f. 1. 2. Fossil. Suisun Bay, California.

D. *ocellata* (S.). — Front view linear, truncate, with conspicuous foramina-like marginal puncta; valves linear elliptic, with 10 costæ in ·001″. SBD. ii. p. 20. St. Abb's Head. The frustules in the front view closely resemble small specimens of *Epithemia Argus*. The extremities of the costæ or canaliculi appear as circular foramina on the f. v., and the costæ on the side view also give an ocellated appearance to the valve, S.

Genus PLAGIOGRAMMA (Grev.) (HETEROMPHALA, E.). — Frustules quadrangular, united into a short fascia; valves with two or more strong, pervious transverse costæ, and moniliform, generally interrupted striæ. Marine. Plagiogramma is a well-marked genus, identical, we believe, with Heteromphala of Ehrenberg. We have adopted the present name, notwithstanding the prior claim of Ehrenberg's, because it is not only better defined, but the latter was founded upon imperfect knowledge, when the lateral view, which is so important, had not been observed. In the front view the terminal puncta are very conspicuous and notch-like, so that the ends appear slightly three-lobed, and the termination of the costæ and striæ are conspicuous along the lateral margins. The valves are always furnished with two central transverse costæ, and frequently with others. In addition to the costæ there are moniliform striæ,—the former pervious, the latter, except in one species, interrupted by a median line. We give Dr. Greville's arrangement of the species, but must express a doubt whether the number of costæ is not variable in the same species.

* *Valves with two centrical costæ.*

PLAGIOGRAMMA *Gregorianum* (Grev.).—Front view with slightly convex margins; valves lanceolate oblong, obtuse; costæ two; striæ pervious, 18 in ·001″. Grev. MJ. vii. p. 208, pl. 10. f. 1, 2. = *Denticula staurophora,* Greg Diat. of Clyde, p. 24, pl. 2. f. 37. Scotland.

P. *Jamaicense* (Grev.). — Front view with straight margins; striæ continued almost to the angles, 16 in ·001″; costæ two. Grev *l. c.* p. 208, pl. 10. f. 3. Jamaica. The striæ can scarcely be termed strictly moniliform, but rather moniliform costæ. Grev.

P.? *tessellatum* (Grev.). — Valves broadly lanceolate, obtuse; striæ interrupted, composed of large subquadrate granules, 8 in ·001″; costæ two. Grev *l. c.* p. 208, t. 10. f. 7. Californian guano.

P. *interruptum* (Greg.). — Front view with slightly convex margins; costæ two; striæ obsolete? = *Denticula interrupta,* Greg Diat. of Clyde, p. 22, pl. 2. f. 30. Scotland. Side view unknown.

2* *Valves with two centrical costæ and one near each end.*

P. *ornatum* (Greg.).—Front view with convex margins, constricted beneath the dilated ends; costæ four; striæ obsolete? = *Denticula ornata,* Greg Diat. of Clyde, p. 22, pl. 2. f. 32. Scotland. Side view unknown.

P. *pulchellum* (Grev.). — Valve linear oblong; costæ four; striæ robust, conspicuously moniliform, interrupted, 11 in ·001″. Grev *l. c.* p. 209, pl. 10. f. 4–6. Californian guano; Jamaica; New Providence.

P. *inæquale* (Grev.).—Front view with straight sides; costæ four, the terminal ones in front view longer than the centrical, and inflected at their apices; striæ moniliform, 16 in ·001″. Grev *l. c.* p. 210, pl. 10. f. 10. Jamaica and New Providence. Side view unknown.

P. *pygmæum* (Grev.).—Minute; valves narrow oblong; costæ four; striæ moniliform, interrupted, 21 in ·001″. Grev *l. c.* p. 211, pl. 10. f. 11. Distinguished for its minute size, its shape, and the small number of striæ, although relatively closer. Grev.

P. *Grevillii* (Ralfs). — Striæ in front view broad, moniliform, costate, 8 or 9 in ·001″; costæ four; connecting zone with longitudinal rows of dots. = *P. ornatum,* Grev *l. c.* p. 209, pl. 10. f. 9. Californian guano. Side view unknown. The striæ are very peculiar, broad, at first sight resembling costæ. Grev.

P. *validum* (Grev.). — Valve linear, slightly dilated in the middle, rounded at the ends; costæ four; striæ interrupted, conspicuously moniliform, 12 in ·001″. Grev *l. c.* p. 209, pl. 10. f. 8. Californian guano. Front view unknown.

P. *obesum* (Grev.). — Minute valves, broadly dilated at the middle and rounded at the ends; costæ four; striæ 11 in ·001″. Grev *l. c.* p. 211, pl. 10. f. 12, 13. New Providence. The inflated appearance of the valves and the small number of striæ render this a well-marked species, Grev.

P. *lyratum* (Grev.). — Valves constricted at the middle, then dilated and narrowly lyriform, linear, and rounded at the extremities; costæ four; striæ 18 in ·001″. Grev *l. c.* p. 211, pl. 10. f. 14. New Providence.

3* *Valves with more than four costæ.*

P. *Californicum* (Grev.). —Valves linear, with rounded ends; costæ more than four; striæ 18 in ·001″. Grev *l. c.* p. 211, pl. 10. f. 15–17. Californian guano.

Doubtful or insufficiently known Species.

P. *lævis* (Greg.). — Front view with slightly but sharply dilated ends and a minute prominence in the middle of each margin; costæ two?, striæ delicate, about 48 in ·001". = *Denticula lævis*, Greg Diat. of Clyde, p. 22, pl. 2. f. 33. Scotland. Side view unknown.

P. *Himantidium* (E.). — Front view eight times as long as broad, with the rounded apices slightly 3-lobed, costæ two?, margin striated. = *Heteromphala Himantidium*, ERBA. 1858, p. 13. Ægean Sea. Side view unknown.

Genus ODONTIDIUM (K.). — Frustules united into a filament; lateral view linear elliptic or cruciform, with pervious costæ. "The Odontidia are merely a filiform series of Denticulæ." (Menegh.) Like Denticula, this genus is distinguished from Fragilaria by its strongly-marked costæ, which appear in the front view like marginal puncta. The filaments are usually extremely fragile, and when broken up the frustules scarcely differ from those of Denticula. Smith says, "It must be acknowledged that there is little to separate these genera; and I should be disposed to unite the two, were there not in the general habit of the living frustule characters which enable the observer to assign them to their respective genera. . . . . It may be left to future observers to consider whether they may not without inconvenience be united."

ODONTIDIUM *mesodon* (K.). — Has shorter and subquadrate frustules, with from two to four transverse costæ. The last character, however, is so inconstant that, although Professor Smith adopted it in his definition, almost every frustule in his figures has a greater number. *O. glaciale* often has trapezoid frustules and 5 or 6 costæ, whilst *O. turgidulum* is intermediate between those forms and the normal frustules in length and number of costæ.

O. *hyemale* (Lyngb., K.). — Front view with bead-like marginal puncta; valves elliptic-oblong or elliptic-lanceolate, obtuse, with conspicuous costæ. KB. p. 44, t. 17. f. 4; SBD. pl. 34. f. 289; *Fragilaria hyemalis*, Lyngb. t. 63; *F. confervoides*, GBF. ii. p. 403; *F. striata*, EA. p. 127; *Odontidium turgidulum*, KB. t. 17. f. 2; *F. turgidulum*, E Inf.; *Odontidium glaciale*, KB.; *O. mesodon*, KB. t. 17. f. 3; SBD. ii. p. 16. Common. Europe, Asia, Australia, and America. (XIII. 24, 25.) *Odontidium hyemale* is easily distinguished from other filamentous Diatoms by its exceeding fragility, minute terminal puncta, gland-like marginal ones, and the conspicuous costæ of the valves. The frustules vary much in length and in the number of their costæ; and several species have, we believe, erroneously been constituted upon these characters. We do not hesitate to unite them, confirmed in our opinion by the doubts expressed respecting their distinctness by the late Professor Smith.

O. *Bogotanum* (Rab.). — Very small; valves oblong, with rounded ends, and from 2 to 4 very broad transverse costæ. Rab Diat. p. 34, t. 2. f. 8. Bogota. Apparently a state of *O. hyemale.*

O. *capitatum* (Rab.). — Four to six times as long as broad; valves lanceolate, constricted beneath the capitate apices; costæ 6 or 7 in 1-1200". Rab Diat. p. 34, t. 10. f. 17. = *O. chamocephalum*, Rab D. p. 34, t. 10. f. 16; *Fragilaria? capitata*, EB. 1853, p. 527; Microg. pl. 35 A. 12. f. 2; *F.? leptocephala*, E *l. c.* p. 527; Microg. pl. 35 A. 12. f. 3. Europe, Persia, and America.

O. *nodulosum* (E., K.). — Frustules narrow linear, twelve times as long as broad; valves narrow linear, nodulose, constricted beneath the capitate ends; striæ 18 in 1-200". KSA. p. 13. = *Fragilaria nodulosa*, EB. 1844, p. 267. Kurdistan.

O. *pinnatum* (E., K.). — Frustules three to six times longer than broad; valves with rounded, not attenuated, ends, and 25 strong striæ in 1-1200". KSA. p. 13. = *Fragilaria pinnata*, EB. 1844, p. 202; Microg. t. 35 A. 22. f. 8. Antarctic Sea.

O. *minimum* (Näg.). — Very small; valves trapezoid, with acute apices and very faint, nearly obsolete transverse striæ; front view quadrate, with marginal puncta. KSA. p. 889. = *O. Salisburgense*, Rab D. p. 38, t. 2. f. 7. Europe.

O. *rotundatum* (E., K.). — Frustules often nine times as long as broad; valves linear, with rounded ends, and

20 stout costæ in 1-1200″. KSA. p. 13. = *Fragilaria rotundata*, EB. 1844, p. 202; EM. pl. 1. 1. f. 1. Fossil. Philippine Islands.

O. *pinnatum* (E., K.).—Frustules three to six times as long as broad; valves linear, with rounded ends, and 15 stout costæ in 1-1200″. KSA. p. 13. = *Fragilaria pinnata*, EA. p. 127; Microg. many figures. Australia, Africa, and America. Akin to *O. striatum* and *O. Syriacum*, E.

O. *striolatum* (E., K.).—Frustules three to six times as long as broad; valves linear, constricted beneath the obtuse capitate ends; striæ about 18 in 1-1200″. KSA. p. 13. = *Fragilaria striolata*, EM. t. 28. f. 58. Europe and Australia. Ehrenberg's figures in the 'Microgeologie' have the ends slightly attenuated, and not capitate.

O. *Syriacum* (E., K.).—Frustules eight times as long as broad; valves with 10 striæ in 1-1200″. KSA. p. 13. = *Fragilaria Syriaca*, EB. 1840, p. 16. Syria.

O.? *polyedrum* (E. K.). — Frustules oblong, angular (sexangular?); three times as long as broad; striæ very fine. KSA. p. 14. = *Fragilaria polyedra*, EB. 1845, p. 77. Fossil. America. 1-900″.

O. *amphiceros* (E., K.).—Valves turgid at the middle, with elongated, linear, truncate ends and pervious striæ. KSA. p. 13. = *Fragilaria amphiceros*, EB. 1844, p. 82; Microg. t. 18. f. 77. Virginia.

O. *granulatum* (E., K.). — With the habit of *O. amphiceros*, but smaller; valves with attenuated ends and granulated fasciæ in striæ. KSA. p. 13. = *Fragilaria granulata*, EB. 1844, p. 202. Antarctic Sea.

O.? *Glans* (E., K.).—Frustules striated, short, gibbous at the middle, constricted at the obtuse ends, and resembling the figure of an acorn with its calyx; striæ 2 or 3 in 1-1200″. KSA. p. 14. = *Fragilaria Glans*, E Inf. p. 185. Fossil. Finland. 1-1150″ to 1-570″.

O. *anomalum* (S.). — Filament tenacious; valves linear, suddenly constricted towards the rounded extremities; costæ four to twelve. SBD. ii. p. 16, pl. 61. f. 376. Alpine situations. Europe. Front view with punctate or denticulate margins. Internal cells, similar to those met with in Meridion and Himantidium, are frequent in this species.

O. *anceps* (E.).—Small; valves linear-oblong, constricted beneath the subcapitate apices. = *Fragilaria anceps*, EA. p. 127; *F. Pteridium*, EM. pl. 34. 5 B. f. 10? North America.

O. *Cretæ* = *Fragilaria Cretæ*, EM. pl. 53. 17. f. 9; *F. paradoxa*, EM. pl. 33. 15. f. 13? Australia, Europe, and Africa. Valves linear-oblong, with rounded ends and pervious transverse costæ.

Genus FRAGILARIA (Lyngb., K.).—Frustules linear, united into a filament; lateral valves smooth or faintly striated, linear-lanceolate or fusiform. Fragilaria differs from Odontidium in the absence of costæ; and the striæ, which are probably present in all the species, are so obscure that Kützing makes their absence one of the generic characters. Diadesmis may be distinguished from Fragilaria by the presence of a central nodule in the lateral valves. Professor Smith justly regrets that in the subdivision of Fragilaria sufficient regard has not been paid to the signification of the generic name. We consider that it would have been far better to have retained the name for *Fragilaria hyemalis*, Lyngb. (=Odontidium, K.), so remarkable for its fragility.

Fragilaria *capucina* (Desm.).—Front view narrow linear, with obsolete or obscure terminal puncta; valves lanceolate; striæ obscure. KB. p. 45, t. 16. f. 3. = *F. pectinalis*, Lyngb. t. 63; Ag Consp Diat. p. 62; *F. tenuis*, Ag Consp Diat. p. 63; *F. Rhabdosoma, diophthalma, multipunctata, bipunctata, angusta, scalaris*, and *fissa*, E Inf. *F. sepes*, EM. t. 38. 1. f. 8. Common, but generally in small quantities and mixed with other Diatoms. Europe, Asia, Australia, Africa, and America. (IX. 173, 174.) A very variable species. The frustules are so much compressed that it is difficult to obtain a good view of the valves; but it may usually be recognized in the front view by its obsolete terminal puncta. When dried, it has a silvery lustre. Filaments elongated.

F. *acuta* (E.). — Valves linear, with acutely cuneate apices; striæ wanting or obscure; front view linear. E Meteorp. t. 2. f. 10; Microg. many figures. = *F. ca-*

pucina, SBD. pl. 35. f. 296. Europe, Asia, Africa, and America. 1-1152″; six times longer than broad.

F. *corrugata* (K.).—Minute; frustules geminate, corrugated at each end; valves acutely lanceolate. KB. p. 45, t. 16. f. 5. Germany. 1-1440″.

F. *pusilla* (K.). — Glassy; frustules rectangular, quadrate, or linear, united in very short fasciæ; valves narrow linear, smooth. KSA. p. 14. Marine. France.

F. *Bacillum* (E.). — Valves smooth, linear with rounded ends, five or six times as long as broad. EB. 1844; Microg. pl. 21. f. 30 & pl. 35. 16. f. 11. Fossil. Oran and Virginia. 1-720″.

F. *glabra* (E.).—Linear, smooth, with attenuated obtuse apices. EA. p. 127. Guiana. May be a variety of *F. biceps*, E.

F. *Catena* (E.). — Twice as long as broad; valves oblong, smooth. EB. 1840, p. 16. = *F. turgens*, EM. several figures? Europe, Africa, and Mexico. 1-1152″.

F. *virescens* (Ralfs). — Valves turgid lanceolate, suddenly contracted towards the obtuse ends; striæ 44 in ·001″, very faint. Ralfs, Ann. xii.; SBD. ii. p. 22, pl. 35. f. 297. = *Diatoma virescens*, HBA. *F. pectinalis*, E. Streams. Europe. Filaments elongated, lurid-green; frustules rather broad, with distinct terminal puncta, frequently irregularly adhering by their angles like a Diatom. Easily recognized by its greenish hue when growing.

F. *Venter* (EM. several figures). — Minute; valves smooth, twice as long as broad, oblong lanceolate, with contracted, produced, obtuse ends.

F. *mesotyla* (E.).—Bacillar with turgid centre, obtuse ends, and transverse granular striæ. Asia. 1-480″. Resembles *Stauroneis granulata*, but wants the longitudinal band and crucial umbilicus, E.

F. *lævis* (E.).—Resembles *Odontidium amphiceros*, but is without the dotted striæ. EA. p. 127. Virginia.

F. *biceps* (E.).—Valves linear oblong, suddenly constricted at the ends into minute beaks; striæ wanting or obscure. EA. p. 127; Microg. several figures. = *F. gibba*, EM. pl. 33. 17. f. 9? America and Europe.

F. *binodis* (E.). — Parasitic, mostly simple; valves rostrate, sometimes constricted, sometimes inflated at the middle; striæ wanting or obscure. EA. p. 127; Microg. pl. 5. 2. f. 26. = *Odontidium? parasiticum*, SBD. ii. p. 19, pl. 60. f. 375. Europe and America. β inflated, without a central constriction. S *l. c.* p. 375. Frustules rarely cohering, and scarcely silicious. S.

F. *constricta* (E.). — Frustules frequently cohering by their angles; valves rostrate, subacute, in general slightly constricted, sometimes inflated at the middle; striæ faint, 42 in ·001″. EA. p. 127; Microg. several figures. = *F. undata*, SBD. ii. p. 24, pl. 60. f. 377. β, valves turgid at the middle, S. Europe, Asia, Australia, and America.

F. *Entomon* (E.). — Valves elongated, smooth, strongly constricted at the middle, with rostrate ends. EA. p. 127; Microg. pl. 5. 3. f. 52. North America.

F. *binalis*, EM. pl. 14. f. 52. Germany and Mauritius. Valves smooth, constricted at the middle, and rounded at the ends.

Doubtful and undescribed Species from Ehrenberg.

F.? *Tessella*, EM. pl. 20. 2. f. 29. Broadly and sharply lanceolate without markings.

F.? *Synedra*, EM. pl. 39. 3. f. 60, 61. Frustules united, curved; venter gibbous at centre.

F.? *Mesogongyla*, EB. 1856, p. 333, f. 48. Africa. Valves with minute inflated middle, and slender acute rostrate ends.

F. *oxyrhambus*, EB. 1856, p. 333, f. 44, Africa; *F. Trachea*, Australia; *F. seminuda*, fossil, Georgia; *F. ventralis*, Anatolia; *F. Himalayæ*, India; *F.? Stylus*, Ægina; *F.? Stylidium*, Ægina; *F.? undulatum*, Asia; *F. Crux*, Asia; *F. Tænia*, Africa; *F. amphilepta*, Africa; *F. Lamella*, Australia; *F. amphicephala*, Asia; *F. ventricosa*, Africa; *F. frustulia*, America; *F. Eunotia*, Africa; *F. thermalis*, America; *F. australis*, America; *F. Pomerooni*, America.

Genus GRAMMONEMA (Ag.).—Frustules similar to those of Fragilaria, but scarcely silicious, and united into flexible, highly mucous filaments. "Grammonema in appearance comes very near to Fragilaria; but its habit is so very different that I am inclined, with Agardh, to keep them distinct. In Fragilaria the filaments do not adhere well to paper, the frustules are silicious and may be subjected to a red heat without any other alteration than the destruction of the colouring matter, and at each end are two, more or less distinct, pellucid puncta. . . . . In Grammonema there is scarcely any silica, and the filaments are not fragile, but highly mucous, adhering firmly to paper or glass, and when dried appearing like a mere stain; the application of nitric acid or of a red heat destroys their form, and I can perceive no puncta at the ends of the frustules." Ralfs, Ehrenberg, and Kützing place this genus with the Desmidieæ because of the absence of silica; and Meneghini says, "I think this conclusion right. It is a true Desmidiean, for it has no silicious shield; and it is to be observed that, however perfectly it may resemble the Fragilarieæ in form, it wants the longitudinal canals and terminal perforations of the primary surfaces."

GRAMMONEMA *Jurgensii* (Ag.). — Valves oblong lanceolate, slightly constricted at the obtuse ends. Ag CD. p. 63. = *Fragilaria Jurgensii*, KSD. p. 59; *Conferva striatula*, Jurg.; *Fragilaria striatula*, Lyngb Hyd Dan. p. 183, t. 63; SBD. ii. pl. 23. f. 298; *Grammatonema striatulum*, KSA. p. 187; *Arthrodesmus striatulus*, ERBA. 1840; *Fragilaria aurea*, Cærm. in Hook B Fl. ii. p. 403. β. *diatomoides*, filaments turning greenish when dried, = *Fragilaria diatomoides*, Grev., Hook B Fl. p. 403. On marine Algæ. Spring, Europe. (xv. 24, 25.) *Grammonema Jurgensii* is easily distinguished from every species of Fragilaria by its marine habitat and flexible, highly mucous filaments.

Genus DIATOMA (Dec.). — Frustules quadrangular, partially separating, and cohering by the angles (generally by the alternate ones), into a zigzag chain. Diatoma is distinguished from Fragilaria and Odontidium by the connexion of the frustules at their angles in a zigzag chain. Some species of Fragilaria, indeed, have a few frustules similarly adhering; but this is a constant character in Diatoma, whilst the greater number of their frustules will present the usual appearance of a Fragilaria. Meneghini says, "For my part, I think it would be much more natural to place the smooth species (*D. pectinale*, *D. vitreum*, and *D. hyalinum*) in Fragilaria; those striated with elliptic-lanceolate surfaces (*D. vulgare*, *D. mesodon*, *D. tenue*, and *D. mesoleptum*) in Odontidium. There would remain as distinctly generic the species which have capitate extremities on their lateral surfaces. These unions would be justified on both sides; for whilst the Odontidia have forms little different from Diatoma, Diatomata are little different from Fragilaria."

* *Striæ obsolete.*

DIATOMA *hyalinum* (K.). — Frustules elongated, very hyaline; valves linear lanceolate, with rather obtuse apices; striæ obsolete. KB. p. 47, t. 17. f. 20; SBD. ii. pl. 41. f. 312. Marine. Europe. (iv. 16.)

D. *minimum* (Ralfs). — Frustules minute, very hyaline; valves about twice as long as broad, oblong with rounded ends; striæ obsolete. Ralfs, T Bot Soc. 2nd ed. p. 20; SBD. ii. p. 41, pl. 41. f. 313. = *D. vitreum*, KB. p. 47. Marine. Europe.

D. *pectinale* (Nitz., K.). — Frustules at first forming a fascia, afterwards zigzag; valves acutely lanceolate; striæ obsolete. KB. p. 47, t. 17. f. 11. = *Bacillaria pectinalis*, Nitz; *B. seriata*, *Ptolemæi*, *flocculosa*, E Inf. Fresh water. Egypt, Europe, England.

2 * *Striæ* (*costæ*) *evident.*

D. *vulgare* (Bory). — Valves spindle-shaped, suddenly contracted at the obtuse ends; costæ pervious, conspicuous, about 18 in ·001". KB. t. 17. f. 15; SBD. p. 39, pl. 40. f. 309; *Bacillaria vulgaris*, E Inf. p. 197; *Diatoma tenue*, Grev., HB Fl. p. 406; *D. flocculosum*, Ag CD. p. 53. Europe, Asia, Africa, and America. Frustules three or four times as long as broad. This species is distinguished by the greater breadth and convexity of its frustules, and by the conspicuous marginal puncta of the front view. (iv. 13; ix. 168.)

D. *mesodon* (K.). — Valves ventricose lanceolate, with three to five transverse striæ at the middle. KB. p. 47, t. 17. f. 13. β. *cuneatum*, frustules cuneate. KB. t. 17. f. 12, = *Bacillaria cuneata*, E

Inf. t. 15. f. 6; *Diatoma cuneatum*, Rab D. t. 2. f. 4. Germany. (IX. 170.) Probably a state of *D. vulgare*.

D. *tenue* (Ag.). — Valves lanceolate, with from 9 to 12 distinct striæ in 1-1200″. Ag CD. p. 52; KB. p. 48, t. 9. f. 10. = *Bacillaria pectinalis*, E Inf. p. 198, t. 15. f. 4. Europe and Asia. A protean species; the frustules are sometimes quadrate, sometimes linear, and sometimes cuneate.

D. *mesoleptum* (K.).—Frustules slightly attenuated at the middle; valves lanceolate, with from 10 to 12 striæ in 1-1200″. KB. p. 48, t. 17. f. 16. Europe. 1-650″. We fear it is scarcely distinct from *D. tenue*.

D. *Ehrenbergii* (K.).—Front view attenuated at the middle; valves linear lanceolate, contracted beneath the subcapitate apices; costæ 11 in 1-1200″. KB. p. 48, t. 17. f. 17; SA. 1857, xix. p. 10, pl. 1. f. 13. = *Bacillaria elongata*, E Inf. p. 198, t. 15. f. 5. Europe. (IX. 169.) The inflation in the centre of the valve separates this species from *D. grande*, which is moreover a larger form with coarser striæ, S. (IV. 15.)

D. *grande* (S.). — Valve linear, constricted beneath the capitate apices; costæ 24 in ·001″. SBD. ii. p. 39, pl. 40. f. 310. = *Bacillaria australis*, EM. pl. 35. A 2. f. 3. Britain, Africa, and South America.

D. *elongatum* (Ag.). — Valves linear, with inflated, capitate apices; costæ 7 in 1-1200″. KB. p. 18, t. 17. f. 18; SBD. ii. p. 40, pl. 40. f. 311. = *Diatoma gracillimum*, Näg., KSA. p. 889. Europe. Front view slender, attenuated at the middle. (IV. 14; IX. 119.)

Genus ASTERIONELLA (Hass.). — "Frustules linear, inflated towards one or both extremities; adhering by their adjacent angles into a star-like filament" (SBD. ii. p. 81). The frustules in this genus exactly resemble those of the capitate species of Diatoma, but are few in number; and being connected by the adjacent angles, the free extremities diverge in a stellate manner. We first observed a single specimen amongst some freshwater Algæ gathered near Dublin by Mr. D. Moore, and afterwards obtained it plentifully for two successive years in a pool near Dolgelly, when we considered it a species of Diatoma nearly allied to *D. tenue*. Subsequently we received a larger form from Professor Dickie, gathered near Aberdeen. The Scottish form had the free end truncated, and is probably the one described by Professor Smith as *A. Ralfsii*.

ASTERIONELLA *formosa* (Hass.). — Front view somewhat more enlarged at the base than at the summit. ·0024″ to ·0031″. SBD. ii. p. 81. Fresh water. Britain. (IV. 17.)

A. *Bleakeleyii* (S.).—Frustules linear, enlarged at the base. ·0022″. SBD. ii. p. 82. Marine. England.

A. *Ralfsii* (S.). — Frustules in front view exactly linear; valve attenuated at one end, constricted towards the other, which is rounded and capitate; striæ obscure. SBD. ii. p. 81. = *Diatoma stellare*, BO. p. 39. Fresh water. Europe and America. (IV. 18.)

Genus NITZSCHIA (Hass., Smith).—" Frustules free, elongated, compressed; valves linear, keeled, with one or more longitudinal lines of puncta; keel frequently eccentric. . . . This genus embraces a large number of species, differing in form and size, but all agreeing in a few general characters. The most important of these is the keeled form of the valves and the remarkable inequality, in many of the species, between the portions of the valve lying on either side of this prominency. This inequality (or, in other words, this eccentricity) of the keel distinguishes Nitzschia from Amphiprora, in which the keel is also present; while the presence of a keel and its accompanying line or lines of puncta, together with the absence of any form of stipes, separate the present from the genus Synedra." Professor Smith, whose generic character and remarks we have quoted, has brought together forms from several genera, and thus has not only pointed out the remarkable character which is common to them all, but also relieved those genera of members which ill agreed with their definitions. It is, however, probable that his characters may rather belong to a family than to a single genus, his sections forming genera. The sigmoid forms were placed by Ehrenberg in Navicula, and by Kützing, in his earlier work (*Kiesel. Bacil.*), in Synedra. Subsequently, however, in his 'Species Algarum,' Kützing removed them from Synedra, and, under his old name of Sigmatella, placed them with the Fragilarieæ because they are not affixed and have pervious transverse striæ.

* *Minute: front view strait; valves arcuate with a row of dots on the ventral margin.*

NITZSCHIA *amphioxys* (E.). — Valve linear lanceolate, arcuate, with convex dorsum, concave venter, and attenuated, subrostrate, acute apices; striæ 30 in ·001", terminating in dots at the ventral margin. SBD. i. p. 40, pl. 13. f. 105. = *Eunotia amphioxys*, EA. p. 125. Fresh water, very common. Ehrenberg gives upwards of 200 habitats in Europe, Asia, Australia, Africa, and America.

N. *vivax* (S.). — Valve linear lanceolate, arcuate, with rostrate apices; striæ distinct, 30 in ·001", terminating in marginal dots. SBD. i. p. 41, pl. 31. f. 267. Fresh or brackish water. England.

N. *parvula* (S.).—Valve with central constriction, obscure puncta, and produced apices; striæ faint, 70 in ·001". SBD. i. p. 41, pl. 13. f. 106. Marine. Sussex.

N. *minutissima* (S.). —Valve linear, with distinct puncta and prominent acute apices; striæ obscure, 72 in ·001". SBD. i. p. 41, pl. 13. f. 107. Fresh water. Beachy Head.

N. *Dianæ* (E.).—Valve linear, arcuate, with convex dorsum, concave venter, and produced slightly reflexed apices; striæ 13 in 1-1200", terminating in dots on the ventral margin. = *Eunotia Dianæ*, ERBA. 1840, p. 14; Microg. pl. 35 A. 2. f. 9. Fresh water. Europe, Asia, Africa, and America.

N. *amphilepta* (E.). — Valve linear, arcuate, with convex, smooth dorsum, slightly concave, striated ventral margin, and acute, gradually attenuated, slightly reflexed apices. = *Eunotia amphilepta*, ERBA. 1845, p. 363; Microg. pl. 34. 8. f. 4. Japan and China.

N. *virgata* (Roper). — Valve linear lanceolate, slightly arcuate, with produced, slightly recurved, obtuse apices; striæ distinct, 26 in ·001", dilated at intervals into ridges on the ventral margin. Roper JMS. vi. p. 23, pl. 3. f. 6. Marine. Tenby. Differs from N. *amphioxys* and N. *vivax* by the striæ being dilated into bands instead of terminating in puncta, Roper.

2 * *Frustules constricted at the middle.*

N. *constricta* (K.).—Front view oblong, slightly constricted at the middle and tapering towards the somewhat truncate ends; keel very eccentric; striæ obscure, 60 in ·001". = *Synedra constricta*, KB. p. 64, t. 3. f. 70; *Nitzschia dubia*, SBD. i. p. 41, f. 112. Marine. Europe.

N. *Entomon* (E.).—Elongate, thick, striate, oblong with constricted middle and obtusely cuneate ends. = *Synedra Entomon*, EM. pl. 34. 2. f. 5. Europe, Asia, Australia, Africa, and America.

N. *plana* (S.). — Front view linear lanceolate, with attenuated middle and acutely cuneate ends; valves acutely linear lanceolate, with a single row of puncta and 56 obscure striæ in ·001. SBD. i. p. 42, pl. 15. f. 114. Brackish water. Europe.

N. *Brightwellii* (Kitton). — Valves broad linear-oblong, with obtuse, shortly attenuated ends, slightly constricted middle and interruptedly striate margin; surface under a low power granular, under a higher, punctato-striate; striæ transverse, 25 to 30 in ·001". Brackish water. Sierra Leone. Kitton *in lit.* (VIII. 7.)

N. *latestriata* (Bréb.). — Front view large, broad linear-oblong, with a central constriction and broadly rounded ends; valves narrow lanceolate, with a central keel, double row of puncta and 56 distinct striæ in ·001". = *Amphiprora latestriata*, Bréb. in KSA. p. 93; *Nitzschia bilobata*, SBD. i. p. 42, pl. 15. f. 113. Marine. Europe.

N. *panduriformis* (Greg.). — Broad linear-oblong, with constricted middle, acuminate ends, and punctuated margins; striæ fine, about 48 in ·001", transverse and oblique. GDC. p. 57, pl. 6. f. 102. Marine. Scotland. There is a faint indication of a double keel in the middle of the valve. The striation is similar to that of *Tryblionella constricta*; but the present form is larger, and distinguished by marginal puncta; still it resembles a Tryblionella about as much as it does a Nitzschia, Greg.

3* *Front view sigmoid* (Sigmatella, Kütz.).

N. *sigmoidea* (Nitzsch, S.).—Front view elongated, broadly linear, sigmoid with truncate ends and marginal puncta; valves narrow linear-lanceolate, with tapering ends and a single longitudinal series of puncta; striæ 85 in ·001″. SBD. i. p. 38, pl. 13. f. 104.=*Navicula sigmoidea*, EI. t. 13. f. 15; *Synedra sigmoidea*, KB. p. 67; *Sigmatella Nitzschia*, KSA. p. 18; *Nitzschia elongata*, Hassall, B Alg. p. 435. Fresh water. Europe. (IX. 148.) Large, with elegantly punctate margins. The striæ in this Diatom are sometimes strong and easily seen, while others in the same slide set at defiance every method of illumination to bring them out. Mr. Sollitt, of Hull, says, "The striæ vary from 65 in the ·001″ up to a degree of fineness which no lenses that we now have will show."

N. *Brébissonii* (Kütz., S.).—Front view broadly linear, sigmoid with truncate ends and marginal puncta; valves linear, with attenuated, obtuse apices; striæ 27 in ·001″. SBD. i. p. 38, pl. 31. f. 266. =*Synedra Armoricana*, KB. t. 4. f. 34; *Sigmatella Brébissonii*, KSA. p. 18. France, England. Resembles *N. sigmoidea*, but is much broader in proportion to its length, the puncta are more conspicuous, and the lateral view is more linear. According to Professor Arnott, this species is not the *Sigmatella Brébissonii* of Kützing, the latter being a mere variety of *N. sigmoidea*, whilst Smith's species is distinct and a brackish-water species.

N. *macilenta* (Greg.).—Front view elongated, linear, sigmoid, truncate; valves linear lanceolate, with acute apices; keel with a single row of subremote puncta; striæ very obscure. Grev MJ. vii. p. 83, pl. 6. f. 8, 9. Marine. Scotland. Allied to *N. sigmoidea*, but decidedly less sigmoid. The side view very narrow; puncta separated from each other by irregular intervals, and fewer (8 in ·001″) than in *N. sigmoidea*, Greville.

N. *Sigma* (K., S.).—Front view sigmoid, linear lanceolate, gradually tapering to the truncated apices; keel of valves with a double row of puncta. SBD. i. p. 39, pl. 13. f. 108.=*Synedra Sigma*, KB. p. 67, t. 30. f. 14. Marine. Europe. Striæ 56 in ·001″, S. (IV. 20.)

N. *Sigmatella* (Greg.).—Front view sigmoid, linear lanceolate, gradually tapering to the obtuse apices; valves linear, acute, with obscure striæ. Greg MJ. iii. p. 4, f. 2. = *N. curvula*, SBD. ii. p. 39. Fresh water. Europe. Distinguished from *N. Sigma* by its far more delicate striæ and freshwater habitat. Professor Kützing describes the *Navicula curvula* as straight in the front and sigmoid in the lateral view; it is therefore probably a Pleurosigma, and not this species, as supposed by Smith.

N. *vermicularis* (K.).—Front view sigmoid, slender, linear or slightly dilated at the middle; striæ obscure.=*Synedra vermicularis*, KB. t. 4, f. 35; *Sigmatella vermicularis*, KSA. p. 18. Fresh water. Europe.

N. *Tergestina* (K.).—Front view sigmoid, linear, truncate; valves narrow linear, with suddenly contracted, produced apices. = *Synedra Tergestina*, KB. p. 66, t. 4. f. 33; *Sigmatella Tergestina*, Rab D. p. 56. Europe. 11 striæ in 1-1200″, Rab.

N. *Italica* (Rab.).—Front view broadly linear, slightly sigmoid, truncate; valves sigmoid, with attenuated rounded ends, and 9 striæ in 1-1200″.=*Sigmatella Italica*, Rab D. p. 56, t. 4. f. 12. Italy.

N. *obtusa* (S.).—Front view sigmoid, linear, with rounded apices; valves linear, obtuse, with a double series of puncta; striæ 56 in ·001″. SBD. i. p. 39, pl. 13. f. 109. Brackish water. Sussex.

N. *Smithii*.—Front view broadly linear, sigmoid, truncate, with conspicuous marginal capitate striæ having smaller puncta interposed between them; valves distinctly striate.=*Nitzschia spectabilis*, SBD. i. p. 39, pl. 14. f. 116. Marine. Britain. Keel nearly central, puncta in four rows. Sm.

4* *Front view lunately curved.*

N. *arcuata* (Greg.).—Front view linear arcuate, with rounded ends; valves lanceolate, obtuse; puncta about 20 in ·001″. Grev. MJ. vii. p. 82, pl. 6. f. 4–7. Marine. Scotland.

5* *Frustules straight in both views, not constricted at the middle.*

† Front view linear.

N. *scalaris* (E., Sm.).—Large; front view broadly linear, with dilated truncate ends and broadly striated margins, the striæ alternately longer and shorter; valves linear with shortly attenuated, obtuse ends. SBD. i. p. 39, pl. 14. f. 115. = *Synedra scalaris*, EA. p. 137, t. 2. 2.

f. 18. Brackish water. Europe, Asia, Australia, and America. (IV. 21.)

N. *spectabilis* (E.).—Large; front view broadly linear, with truncated cuneate apices; valves with rounded ends. = *Synedra spectabilis*, EA. and M, several figures. Europe, Asia, Australia, Africa, and America. The valves are figured as elongated, narrow linear, with suddenly attenuated, obtuse, reflected apices, and a row of puncta on one margin.

N. *insignis* (Greg.). — Front view broadly linear, with rounded ends and conspicuous marginal puncta and striæ; valves linear lanceolate, straight or slightly sigmoid, with subcentral keel and 30 distinct striæ in ·001″. Greg. MT. v. pl. 1. f. 46. Marine. Scotland. Distinguished from *N. sigmoidea* and *N. Brébissonii* by its straight front view; and from *N. scalaris* by its finer markings, more slender form, and nondilated ends. Greg.

N. *gigantea* (E.).—Very large, linear, with suddenly rounded ends; valves with attenuate subacute apices; surface finely striated in the intervals of the pinnules. = *Synedra gigantea*, ERBA. 1841, p. 22; *Synedra Libyca*, KSA. p. 48. Oasis of Jupiter Ammon, 1-60″.

N. *linearis* (Ag., S.). — Front view linear, with rounded or truncate apices and nearly central keel; puncta in a single row; striæ obscure. SBD. i. p. 39, pl. 13 & pl. 38. f. 110. = *Frustulia linearis*, Ag. Fresh water. Europe.

N. *Palea* (K., S.).—Front view linear; valves narrow, lanceolate, acute. SBD. ii. p. 89. = *Synedra Palea*, KB. p. 63, t. 4. f. 2; *Synedra Fusidium*, KB. p. 64, t. 30. f. 33; *Synedra fusidioides*, Rab D. p. 53, t. 4. f. 47. Europe. Frustules minute.

N. *tenuis* (S.). — Front view linear, truncate; valves narrow, lanceolate, acute; striæ obscure. SBD. i. p. 40, pl. 13. f. 111. Fresh water. England.

2 † Extremities, in front view, with a hyaline wing or expansion on each side.

N. *spathulata* (Bréb.).—Front view lanceolate, with the truncate ends dilated on each side; valves lanceolate acute, with a single row of puncta. SBD. i. p. 40, pl. 31. f. 268. Marine. France and England.

N. *distans* (Greg.).—Front view broad, sublinear, with distant irregularly disposed marginal puncta; apices truncate with a slight hyaline expansion on each side. GDC. p. 58, pl. 6. f. 103. Marine. Scotland. Valves lanceolate, with acute apices and central keel.

N. *hyalina* (Greg.).—Front view sublinear, with small, regular marginal puncta; valves narrow linear, with contracted, produced apices and central keel. GDC. p. 58, pl. 6. f. 104. Marine. Scotland. Keel apparently double; but perhaps one is seen through the very hyaline valve. Greg.

3 † Front view lanceolate.

N. *angularis* (S.).—Front view rhomboid-lanceolate, truncate; valves lanceolate, with central keel; puncta in a single series and longitudinal lines. SBD. i. p. 40, pl. 13. f. 117. Marine. Sussex. This and the following species ought perhaps to be placed in Ceratoneis.

N. *lanceolata* (S.).—Front view broadly lanceolate, acute; valves lanceolate, rostrate, acute, with eccentric keel and longitudinal lines. SBD. p. 40, pl. 14. f. 118. Marine. Sussex.

Doubtful or insufficiently described Species.

N. *valens* (E.). — Very large, broadly linear, finely striated, with truncate ends. = *Synedra valens*, EA. t. 3. 2. f. 6. Fresh water. (XII. 44.) Mexico and United States.

N. *curvula* (K.).—Elongated, curved; front view slightly attenuated towards the truncate apices; valves acuminated, subacute, sometimes with a longitudinal punctate line. = *Synedra curvula*, KB. p. 65, t. 15. f. 2. Fresh water. Prussia. 1-240″.

N. *Ehrenbergii* = *Synedra amphilepta*, EM. pp. 34–5, f. 11. Cape Verd. Elongated, straight, linear, with striated margins and acutely cuneate apices.

Genus CERATONEIS (Ehr.).—Frustules as in Nitzschia, but with long rostrate ends, and usually with a more or less evident central pseudo-nodule. Professor Smith, after excluding some of its species, made Ceratoneis a section of Nitzschia, and perhaps was justified in so doing; but as the forms included in it are remarkable for their filiform beaks, and there is some appearance of a central nodule, we have retained the genus, at least for the present. Some of the species resemble the Closteria in form, and have been referred to as showing an affinity between the Diatomaceæ and the Desmidieæ. The resemblance, however, is merely superficial, and, instead of showing an affinity, rather proves it does not exist. In the Closteria, division takes place across the lunate frond, or in the shortest diameter, whilst in this genus it occurs in the opposite direction.

CERATONEIS *longissima* (Bréb.).—Valves lanceolate, with very long straight slender awns, a subcentral keel, a single row of puncta, and obscure striæ. KSA. p. 891. = *Nitzschia birostrata*, SBD. i. p. 42, pl. 14. f. 119. Marine. France, England. Front view straight, with lanceolate middle, and long, linear, truncated beaks. (IV. 22.)

C. *Closterium* (E.).—Front view arcuate, with lanceolate middle, and long, filiform, incurved awns; valves faintly striated, with central keel and a single row of puncta. Ehr. leb. Kreidethierchen. t. 4. f. 7. = *Nitzschia Closterium*, SBD. i. p. 42, pl. 15. f. 120. Europe. (XII. 59.)

C. *reversa* (Sm.).—Front view lanceolate, with long beaks, the extremities of which are bent in opposite directions; puncta obsolete; striæ obscure, 48 in ·001″. = *Nitzschia reversa*, SBD. i. p. 43, pl. 15. f. 121. Brackish water. Europe.

C. *spiralis* (K.). — Lanceolate, with long, flat, spirally-twisted beaks. KB. p. 104, t. 4. f. 38. Marine. Europe. (XIII. 9.)

C. *subulata* (Bréb.). — Lanceolate subulate, very slender, smooth, gradually tapering into slender beaks, which are sometimes straight, sometimes curved or sigmoid. KSA. p. 89. Marine. France.

C. *acicularis* (K.).—Front view narrow linear; valves lanceolate, with straight, slender beak; striæ obscure. = *Synedra acicularis*, KB. p. 63, t. 4. f. 3; *Nitzschia acicularis*, SBD. p. 43, pl. 15. f. 122. Fresh water. Europe.

C. *gracilis* (Bréb.).—Elongated, very slender, linear, with rather obtuse straight, curved, or sigmoid beaks; striæ obscure. KSA. p. 89. = *Nitzschia Tænia*, SBD. p. 43, pl. 15. f. 123. Fresh or brackish water. Europe.

Doubtful Species.

C. *Cretæ* (E.). — Smooth, navicular, very slightly constricted at the middle, with acute, straight, not much produced apices. ERBA. 1844; Microg. pl. 22. f. 61. Fossil. Sicily. The figure shows a distinct median line and nodule.

C. *laminaris* (E.).—Broadly lanceolate, with striated margins and short rostrate apices. EA. t. 3. 7. f. 24. Asia and America. Valve with median line and central nodule.

C. *Linea*. = *Synedra Linea*, EM. pl. 18. f. 78. Fossil. Virginia. Lanceolate, with punctated margins, and narrow-linear, rostrate ends.

C. *rhomboides* (E.).—India.

Genus AMPHIPLEURA (Kütz.).—Frustules simple, elongated; valves with longitudinal ridges. An ill-defined genus, the species of which differ considerably in their appearance.

AMPHIPLEURA *pellucida* (K.).—Frustules slender, hyaline; valves narrow lanceolate, with rather obtuse apices. KB. p. 103, t. 3. f. 32; SBD. pl. 15. f. 127. = *Navicula pellucida*, Ehr Inf. t. 13; *Aulacocystis pellucida*, Hass Algæ, p. 427, pl. 102. f. 8. Fresh water. Europe. (IV. 30, IX. 140 & XIII. 1.) 1-300″ to 1-140″. Frustules often connected in flat, longitudinal band-like series by a mucous covering.

A. *Danica* (K.).—Lanceolate, obtuse or truncated, smooth. KB. p. 103, t. 30. f. 38. Marine. Europe. 1-390″.

A. *rigida* (K.). — Elongated, linear lanceolate, with truncate ends; front view straight; valves slightly sigmoid. KB. p. 104, t. 4. f. 30. = *Amphipleura sigmoidea*, SBD. i. p. 45, pl. 15. f. 128. Marine. Europe. (XIII. 2.) It forms brown stain-like patches on marine rocks, and scarcely changes colour when gathered.

A. *inflexa* (Bréb.).—Valves linear, lunately curved, slightly attenuated, somewhat constricted beneath the rounded apices. KSA. p. 88. Marine. (IV. 31.) France and Britain. 1-430″ to 1-336″. Striæ close, usually very indistinct. In mode of growth and colour it resembles *A. rigida*, but changes to a green colour as soon as gathered.

FAMILY V.—SURIRELLEÆ.

Frustules prismatic or subdisciform; striæ of the lateral surfaces either interrupted by a longitudinal line or radiate. The Surirelleæ comprise by no means a satisfactory group, and we believe that Synedra and the other genera with wand-like frustules should be removed from this family, whether they be united to the Fragilarieæ or retained together as a distinct family; but the object of this work is rather to present an epitome of what has already been done than to introduce any extensive alterations. "The genus Campylodiscus is near to the Melosireæ, but the disk is not circular but elliptical. Surirella and the free frustules of Synedra are related to the Naviculeæ, but they want the middle clearly-defined nodule in the secondary sides. Bacillaria is closely allied to the Fragilarieæ, especially to Diatoma; but the striæ of the frustule are interrupted in the middle, while in Diatoma they are pervious. . . . . Comparing together the genera Campylodiscus, Surirella, Bacillaria, Synedra, it is easily perceived that the last two only deviate from the Fragilarieæ by the character of interrupted striæ; and the first two, deviating sensibly in the succession of species from the circular shape of the lateral surfaces, or of the transverse section, establish a transition between the Melosireæ, and the group formed of these two genera, along with the Fragilarieæ and the Meridieæ. Hence it is impossible to establish an organographical character that shall embrace the entire family and strictly represent its type." (Meneg.)

Genus BACILLARIA (Gmel.).—Frustules linear, straight, united into a short band, moving on each other by a sliding motion without separation; valves having a longitudinal punctated keel. The elongated wand-like frustules distinguish this from all other genera, except some species of Diatoma and Synedra. It differs from the former by the frustules not forming zigzag chains, and from the latter by its band-like filaments. "The principal organographical character that distinguishes Bacillaria from the Fragilarieæ is the same that allies it to a different group of the family, viz. the interruption of the transverse striæ in the median line of the secondary surfaces, to which is added the parallelism of the primary surfaces." (Menegh.)

* *Frustules united into a short band.*

Bacillaria *paradoxa* (Gmel.). — Valves linear lanceolate, E Inf. p. 195; SBD. pl. 32. f. 279. Ditches in salt marshes. Europe. (IV. 18; IX. 166, 167.)

2* *Frustules bundled.*

B. *cursoria* (Donkin).—Valves lanceolate, hyaline; striæ obsolete. Donkin, TMS. vi. p. 16, pl. 3. f. 12. Marine. England. (IV. 19.)

B. *socialis* (Greg.).—Valves lanceolate, with fine, but distinct, transverse striæ. = *Nitzschia socialis*, Greg. TMS. v. p. 8, pl. 1. f. 45. Marine. Scotland. Frustules in groups, striæ 30 to 36 in ·001. Greg.

Genus HOMŒOCLADIA (Ag.). — Frustules bacillar, Nitzschoid, within subular, submembranaceous, branched filaments. The frustules are usually fasciculated; and their structure, which is that of the genus Nitzschia, separates the present from the other frondose genera (Sm.). When dried, the filaments become opake, and usually acquire a metallic lustre.

Homœocladia *Martiana* (Ag.).—Frond umbellately branched, membranaceous, rugose, opake when dried; frustules crowded, linear, elongated, obtuse. Ag. CD. p. 25; KB. p. 110, t. 30. f. 83. = *H. Anglica*, Ralfs, Annals, xvi. pl. 3. f. 1. Marine. Europe. (IV. 2, 3; XIV. 47–49.) Fronds much branched, flaccid when recent, and of a dark olive-colour, with a metallic lustre and transversely wrinkled when dried.

H. *Anglica* (Ag.). — Frond trichotomous below, dichotomous above, opake when dry, scarcely rugose; frustules very long, linear, obtuse. Ag CD. p. 25; KB. t. 30. f. 82. France and England. Does not adhere to paper. We are unable to determine from the fragments we have examined whether this is truly distinct from *H. Martiana*.

H. *Arbuscula* (K.).—Very much and umbellately branched, upper branches fascicular, capillary, spuriously jointed; frustules linear, elongated, obtuse, smooth. KB. p. 111, t. 22. f. 11. Marine. Venice. 1-7''.

H. *dilatata* (K.).—Much branched, setaceous, branches fastigiate, incrassated above, clavate; fasciculi closely contiguous; frustules linear, elongated, acicular, obtuse. KB. p. 111, t. 23. f. 1. Marine. Adriatic. 1-12''.

H. *moniliformis* (Kütz.).—Capillary; branches slender, elongated, moniliform; fasciculi of frustules remote; frustules very long linear, obtuse. KB. p. 110, t. 22. f. 10. Adriatic. (xiv. 45, 46.)

H. *pumila* (Ag., K.).—Irregularly divided into equal, obsoletely-articulated, capillary branches; frustules short linear, with rounded ends. KB. p. 110, t. 22. f. 9. = *Schizonema pumilum*, Ag CD. p. 16. Adriatic. (xiv. 37, 38.)

H. *penicillata* (Kütz.). — Fastigiately branched; branches divaricate, fastigiately divided; terminal ramuli white, in pencils; primary tube thick, gelatinous cartilaginous; frustules densely aggregated, slender, linear acicular, very narrow. KSA. p. 97. France.

H. *lubrica* (Me., K.). — Gelatinous, green, setaceous, for the most part divided at the apex; frustules fasciculate, densely aggregated, linear. KSA. p. 98. = *Schizonema lubricum*, Menegh. Adriatic.

H. *filiformis* (S.).—Frond simple; fascicles of 3 or 4 frustules; front view linear-lanceolate, obtuse; valves linear lanceolate, subacute. SBD. ii. p. 80, pl. 55. f. 348. Brackish and fresh water. England. (iv. 25.)

H. *sigmoidea* (S.). — Frond simple; frustules irregularly fasciculated in bundles of about 6; front view sigmoid; valves linear, with attenuated ends. SBD. ii. p. 81, pl. 55. f. 349. Brackish water. Britain. (iv. 26.)

Genus SYNEDRA (Ehr.).—Frustules elongated, wand-like, attached by the lower end, lateral surfaces equal to or less than the front view, traversed by a smooth median longitudinal line. The true species of Synedra are distinguished from all other genera by their wand-like form and attachment by one end. They are usually either fasciculated or fixed to a distinct stipes in a fan-like manner. "As to the organographical considerations which can be instituted in this genus, they reduce themselves to the single one of length predominating over breadth and the eminently bacillary form derived from it. Thus Kützing observed of the opposite characters of Synedra and Surirella, that the lateral surfaces exceeded in one the primary surfaces in the other." Several of the species at present placed in this genus may prove, when better known, to belong to Nitzschia.

* *Minute; attachment slight; striæ indistinct or obsolete.*

SYNEDRA *quadrangula* (K.). — Very minute, in one view narrowly linear, in the other broad quadrangular. KB. p. 63, t. 3. f. 23. Marine. Norway.

S. *Atomus* (K., Näg).—Very minute, in one view elliptic with rounded apices, in the other linear truncate. KSA. p. 40. = *Amphora Atomus*, KB. t. 30. f. 70; *Synedra minutissima, β pelliculosa*, K. (according to M. de Brébisson). Fresh water. Europe.

S. *perpusilla* (K.).—Very minute; front view very narrow linear; valves lanceolate, contracted near the obtuse apices. KB. p. 63, t. 3. f. 31. Venice.

S. *Biasolettiana* (K.).—Very minute; front view very narrow linear, arcuate; valves lanceolate, obtuse. KB. p. 63, t. 3. f. 22. Fresh water. Trieste.

S. *pusilla* (K.).—Minute; front view broadly linear; valves oblong-elliptic, with somewhat rounded apices. KB. p. 63, t. 3. f. 29. Carlsbad. 1-1800''.

S. *angustata* (K.). Front view very narrow linear; valves broader, oblong, with attenuated, rather obtuse apices. KB. p. 64, t. 4. f. 1, 3. Hot springs. Italy. 1-720''.

S. *virginalis* (K.).—Front view linear, truncate, with attenuated centre; valves lanceolate. KB. p. 64, t. 3. f. 15. Genoa. 1-600''.

S. *ventricosa* (Rab.).—Front view narrow linear; valves ventricose, with short, produced, beak-like apices. Rab D. p. 52, t. 4. f. 36. Apennines.

2* *Frustules in lateral view arcuate.*

S. *lunaris* (E.).—Valves narrow, linear, arcuate, slightly attenuated, obtuse; striæ faint, 36 in ·001''. EI. t. 17. f. 4; SBD. i. p. 69, pl. 11. f. 82. Fresh water. Common. Europe, Asia, and America.

(x. 185.) Frustules affixed, often aggregated.

S. *falcata* (K.).—Valves arcuate, linear, with obtuse apices, faint striæ, undulated venter. KSA. p. 43. Paris.

S. *bilunaris* (E.). — Valves linear, curved, bilunate, obtuse, attached, more attenuated at base; striæ obscure. EI. t. 17. f. 5. Fresh water. Europe. Valves bent inwards at the middle, so as to become bilunate.

S. *longissima* (Sm.).—Valve much elongated, slightly and gradually attenuated, with capitate apices; striæ 28 in ·001″. SBD. i. p. 72, pl. 12. f. 95. Botanic Garden, Belfast. Is this distinct from *S. biceps*?

S. *biceps* (K.).—Much elongated; valves very slender, gradually attenuated, with capitate apices and distinct transverse striæ. KB. p. 66, t. 14. f. 18. Fresh water. Europe. 1-100″ to 1-60″. Front view linear, with striated margins, sometimes dilated at the ends.

S. *alpina* (Näg.). — Slender, faintly striated; front view straight, linear; valves arcuate, very narrow lanceolate, with produced capitate apices. KSA. p. 43. Switzerland. 1-600″ to 1-336″.

S. *subarcuata* (Näg.).—Small; front view straight, linear, valves slightly arcuate, with produced capitate apices. 1-2400″ to 1-1200″. Switzerland. Like *S. alpina*, but only half the size. Rab.

S. *flexuosa* (Bréb.).—Front view broadly linear; valves linear, curved, sometimes flexuose, with capitate apices and very fine transverse striæ. = *Eunotia flexuosa*, KSA. p. 6; *S. biceps*, SBD. i. pl. 11. f. 83. Fresh water. France, England. β, valves two or three times flexed. Differs from *S. biceps* in having linear, not tapering valves.

S. *pachycephala* (K.). — Front view slender, linear; valves linear, slightly arcuate, with claviform apices and indistinct striæ. = *Eunotia pachycephala*, KSA. p. 6. Fresh water. Europe.

S. *arcuata* (Näg.). — Smooth; front view straight, linear, with truncate ends; valves linear, arcuate, with rounded apices. KSA. p. 890. Switzerland.

S. *gibbosa* (R.).—Front view linear; valves arcuate, tapering to the slightly constricted recurved apices; venter concave, gibbous at the middle. = *Navicula Arcus*, EI. p. 182; *Cymbella Arcus*, HBA. p. 429; *Ceratoneis Arcus*, KB. p. 104, t. 6. f. 10; *Eunotia Arcus*, SBD. i. p. 15, pl. 2. f. 15. Fresh water. Europe. The frustules are affixed, as in other species of Synedra.

S. *hamata* (S.). — Valves linear or linear-lanceolate, with suddenly constricted, produced, incurved apices; striæ marginal, 30 in ·001″. SBD. i. p. 73, pl. 30. f. 264. Fresh water. Sussex.

3 * *Valves straight, with a circular, definite central pseudo-nodule.*

S. *pulchella* (Ralfs, Kütz.).—Frustules in fan-shaped clusters on a compressed-dichotomous stipes; valves lanceolate, obtuse, with a median umbilicus. KB. p. 68, t. 29. f. 87; SBD. i. p. 70, f. 84. = *Ctenophora pulchella*, Bréb., *Synedra Vertebra*, Greg. MJ. iii. pl. 4. f. 22. Ponds and slow streams. England and France. Striæ 33 in ·001″, Sm.

S. *minutissima* (K.).—Very minute; front view narrow linear; valves lanceolate, rather obtuse; striæ 36 in ·001″. KB. p. 63, t. 3. f. 30; SBD. pl. 11. f. 87. Fresh water. Europe.

S. *gracilis* (K.). — Frustules affixed, scattered; valves lanceolate, acute, with a median pseudo-nodule. KB. p. 64, t. 15. f. 8; SBD. i. p. 70, pl. 11. f. 85. Marine. Europe. Striæ obscure, 39 in ·001″, Sm.

S. *Smithii* (R.).—Frustules irregularly affixed; valves lanceolate, acute, with 36 very faint striæ in ·001.″ = *Synedra acicularis*, SBD. i. p. 70, pl. 11. f. 86. Brackish water. England.

4 * *Valves with very long awn-like beaks* (Toxarium); *nodule obsolete.*

S. *undulata* (Bailey).—Valves slender, lanceolate at the middle, tapering into very long, linear, undulated awns, with clavate apices. SBD. ii. p. 97; Greg. DC. p. 59, pl. 6. f. 107. = *Toxarium undulatum*, Bailey, MC. p. 15, figs. 24, 25. Marine. America and Europe. Front view linear, broader; valves arcuate or straight, with 24 moniliform striæ in ·001″.

S. *Hennedyana* (Greg.).—Frustules as in *S. undulata*, but the awns not undulate. GDC. p. 60, pl. 6. f. 108. Marine. Scotland.

5 * *Frustules affixed, aggregated or scattered; pseudo-nodule obscure or indefinite.*

S. *parvula* (K.).—Front view linear, truncate; valves broad lanceolate, acute. KB. p. 64, t. 30. f. 32. Fresh water. Germany and France. 1-1200″. Sometimes free, sometimes attached and densely aggregated in a radiant manner.

S. *subtilis* (K.). — Slender, radiant; valves narrow linear-lanceolate, very acute. KB. p. 64, t. 14. f. 2*a*. = *Navicula*

Acus, E Inf. p. 176, t. 13. f. 4. (IX. 147.) Germany and France.

S. *dissipata* (K.).—Slender, affixed, radiant; front view narrow linear, truncate; valves narrow lanceolate, acute. KB. p. 64, t. 14. f. 3. = *S. fasciculata*, EI. t. 17. f. 3. Fresh water. Europe, Australia, and Asia.

S. *famelica* (K.).—Delicate, irregularly aggregated, very narrow linear, truncate in lateral view, front view rather acute. KB. p. 64, t. 14. f. 8. 1. Fresh water. Germany. Is a somewhat larger form of *S. dissipata*, Rab.

S. *radians* (K.).—Delicate, densely aggregated, radiant; front view very narrow linear, truncate; valves narrow lanceolate, rather obtuse. KB. p. 64, t. 14. f. 7. Europe. 1-600″. A minute species.

S. *tenuissima* (K.). — Very slender, elongated; front view exactly linear, truncate; valves acicular, acute. KB. p. 64, t. 14. f. 6. Stagnant waters. Germany and France. 1-180″.

S. *tenuis* (K.).—Slender, elongated; front view exactly linear, truncate; valves narrow lanceolate, with somewhat obtuse apices. KB. p. 65, t. 14. f. 12. Fresh water. Germany and France. 1-168″.

S. *Acula* (K.). — Slender, elongated, lanceolate, in front view truncate, in lateral view very acute. KB. p. 65, t. 14. f. 20. Fresh water. Dalmatia and France. 1-72″.

S. *lævis* (E.).—Slightly and irregularly affixed; front view slightly attenuated, truncate; valves more attenuated, obtuse. EA. t. 2. 6. f. 2. Marine. Europe and America. 1-130″.

S. *gracillima* (Rab.).—Front view elongated, very narrow linear; valves linear, acicular, acute. Rab D. p. 53, t. 4. f. 20 *d, e*. Dresden.

S. *salina* (S.). — Valves lanceolate, gradually tapering towards the somewhat obtuse apices; striæ distinct, 32 in ·001″. SBD. i. p. 71, pl. 11. f. 88. Marine. England.

S. *apiculata* (Rab.).—Very slender; valves linear, acicular, with shortly tapering apices, faintly striated. Rab D. p. 56, t. 5. f. 20 *a, b, c*. Dresden.

S. *amphicephala* (K.).—Slender; front view linear, truncate; valves narrow lanceolate, tapering, with capitate apices. KB. p. 64, t. 3. f. 12. Fresh water. Germany. 1-360″.

S. *fontinalis* (S.).—Frustules scattered; valves linear-lanceolate or elliptic-lanceolate, with produced, subcapitate apices; nodule indefinite; striæ 27 in ·001″, Sm ANH. 1857, p. 9, pl. 1. f. 9. Fresh water. Pyrenees.

S. *gibba* (E.).—Smooth, fasciculated, elongated, narrow linear; valves broadly tumid at the middle, with gradually attenuated, obtuse apices. EA. p. 137. United States.

S. *delicatissima* (S.). — Valves elongated, very narrow, gradually tapering to the subacute apices; striæ 27 in ·001″. SBD. i. p. 72, pl. 12. f. 94. Pseudo-nodule indefinite.

S. *tenera* (S.). — Frustules clustered; valve nearly linear or attenuated towards the slightly inflated apices; nodule indefinite; striæ 60 in ·001″. SBD. ii. p. 98. Fresh water. Britain. In outline not unlike *S. delicatissima*, but far smaller and with more delicate striæ, Sm.

S. *lanceolata* (K.).—Front view narrow linear, with slightly dilated apices; valves lanceolate, distinctly striated, with a blank, rhomboid median space. KB. p. 66, t. 30. f. 31. America. 1-600″ to 1-310″.

S. *debilis* (K.).—Minute; front view slightly attenuated, truncate, with obsoletely striated margins; valves lanceolate, with produced apices. KB. p. 65, t. 3. f. 45. = *S. porrecta*, Rab D. p. 55, pl. 4. f. 27. Stagnant waters. Europe, common.

S. *mesolepta* (K.).—Delicate; front view dilated at the ends; valves lanceolate, curved or slightly sigmoid. KB. p. 66, t. 30. f. 30. America. 1-160″.

S. *notata* (K.).—Small, with obsoletely striated margins; front view quadrangular; valves elliptic-oblong, with obtuse ends. KB. p. 65, t. 3. f. 33. Stagnant waters. Europe. 1-650″.

S. *Martensiana* (K.). — Small, distinctly striated; front view linear, truncate; valves rather broader, lanceolate, subacute. KB. p. 65, t. 3. f. 9. Marine. Europe.

S. *Vaucheriæ* (K.).—Minute; front view linear, truncate; valves linear-lanceolate with somewhat produced ends, indefinite pseudo-nodule, and 30 marginal striæ in ·001″. KB. p. 65, t. 14. f. 4; SBD. i. p. 73, pl. 11. f. 99. Fresh water, especially on species of Vaucheria. Europe.

S. *æqualis* (K.). — Front view dilated at the ends; valves linear, with rounded apices, indefinite pseudo-nodule, and 24 striæ in ·001″. KB. p. 66, t. 14. f. 14. = *S. obtusa*, SBD. i. p. 71, pl. 11. f. 92. Stagnant waters. Europe. 1-140″.

S. *investiens* (S.). — Valves linear,

slightly attenuated towards the rounded apices, nodule obsolete; striæ 26 in ·001″. SBD. ii. p. 98. Marine. Scotland.

S. *acuta* (E.).—Front view exactly linear, truncate; valves linear, striated, suddenly acuminated near the apices. EA. t. 1. 2. f. 22. America, Asia, Australia, and Africa. 1-144″.

S. *Oxyrhynchus* (K.). — Front view linear; valves linear, narrower, suddenly contracted into a beak at the ends. KB. p. 66, t. 14. f. 9–11. Germany. Distinguished from *S. acuta* by its constricted ends.

S. *vitrea* (K.).—Front view with dilated apices; valves linear, with suddenly attenuated, obtuse ends. KB. p. 66, t. 14. f. 17. France. Distinguished from *S. Oxyrhynchus* only by its dilated ends in the front view, Rab.

S. *amphirhynchus* (E.).—Large; front view linear, not dilated at the ends; valves contracted into obtuse beaks. EA. t. 3. 1. f. 25. Fresh water. Europe, Africa, and America. 1-120″ to 1-96″. No large, median, smooth space.

S. *præmorsa* (E.).—Front view broadly linear, with truncated, cuneate apices; valves linear, with rounded cuneate ends. EA. t. 3. 6. f. 11. Mexico.

S. *deformis* (S.).—Valves linear or linear-elliptical, suddenly constricted towards the produced and often distorted extremities; nodule obsolete; striæ 36 in ·001″. SBD. ii. p. 98. Fresh water. Sussex.

S. *Ulna* (E.). — Front view exactly linear; valves linear, slightly attenuated near the obtuse apices. E Inf. t. 17. f. 1; SBD. i. p. 71, pl. 11. f. 90. Fresh water. Europe, Asia, Australia, Africa, and America. (x. 184.) 1-280″ to 1-100″. Striæ 24 in ·001″, Sm.

S. *splendens* (K.).—Large, elongated; front view with dilated truncate ends; valves lanceolate, obtuse. KB. p. 66, t. 14. f. 16. = *S. radians*, SBD. i. p. 71, in part. Fresh water. Europe, Asia, and Africa. 1-72″. Differs from *S. Ulna* merely in its dilated apices, Rab.

S. *Danica* (K.).—Slender; front view with dilated, truncate ends; valves lanceolate with slightly clavate apices. KB. p. 66, t. 14. f. 13. Stagnant waters. Europe. 1-140″. Is only a more slender form of *S. splendens*, Rab.

S. *mesocampa* (Bréb.).—Size and form of *S. Ulna*, but in the lateral view flexed at the middle. KSA. p. 44. France.

S. *capitata* (E.).—Valves linear, with the extremities dilated into a triangular head; striæ 23 in ·001″. E Inf. t. 21. f. 28; SBD. i. p. 72, pl. 12. f. 93. Fresh water. Europe, Asia, Africa, and America. (IV. 29; x. 185.) Very large; length 1-120″ to 1-40″.

S. *longiceps* (E.).—Very large, in form approaching very near to *S. capitata*, but with styliform, produced apices. ERBA. 1845. Fresh water. America. 1-12″ to 1-144″.

6 * *Frustules attached by a distinct, mostly persistent, stipes; pseudo-nodule obsolete or indefinite.*

† Frustules in fan-shaped clusters on a short, mostly simple, stipes.

S. *Acus* (Kütz.).—Slender, smooth; front view slightly attenuated, truncate; valves very narrow lanceolate, acicular. KB. p. 68, t. 15. f. 7. Hamburgh. 1-960″.

S. *familiaris* (K.).—Smooth, distinctly tabellate and flabellately disrupted; front view slightly attenuated near the truncate ends; valves lanceolate, acute. KB. p. 68, t. 15. f. 12. France. 1-320″.

S. *parva* (K.).—Minute, smooth, narrow linear, truncate; valves narrow lanceolate. KB. p. 67, t. 15. f. 9. Marine. Italy. 1-960″.

S. *socialis* (Rab.).—Front view linear, with truncated, cuneate ends; valves lanceolate, distinctly striated. Rab D. p. 56, t. 4. f. 22. Fresh water. Italy.

S. *Gallionii* (E.).—Frustules large, on a thick, convex stipes; valves lanceolate; striæ 36 in ·001″, interrupted by a median line. E Inf. t. 17. f. 2; SBD. i. p. 74, pl. 30. f. 265. Marine. Europe, Asia, Africa, and America. (XII. 34, 36.) 1-120″ to 1-100″.

S. *fasciculata* (Ag., K.).—Frustules tabulate, on a thick, hemispherical stipes; front view linear, with subattenuate, truncate apices; valves lanceolate. KB. p. 68, t. 15. f. 5. = *Diatoma fasciculatum*, Ag CD. p. 51. Marine. Common.

S. *tabulata* (Ag., K.).—Frustules large, on a thick, abbreviated stipes; front view broadly linear, truncate; valves lanceolate, with subcapitate apices; striæ marginal, 27 in ·001″. KB. p. 68, t. 15. f. 10; SBD. pl. 12. f. 96. = *Diatoma tabulatum*, Ag CD. p. 50. Marine. Europe.

S. *affinis* (K.).—Frustules subtabulate, on a hemispherical stipes; front view slender, linear, with subattenuate truncate apices; valves lanceolate, acute, with 32 marginal striæ in ·001″. KB. p. 68, t. 15. f. 6, 11; SBD. i. p. 73. Marine. Europe. 1-320″. Frustules united in flabellate or radiating bundles, Sm.

S. *barbatula* (K.).—Minute, tabulate; front view linear, truncate, with a terminal mucous appendage; valves elliptic-lanceolate. KB. p. 68, t. 15. f. 10. 4. Marine. Europe. 1-960″.

S. *truncata* (Grev.).—Frustules united in tablets, obscurely stipitate; front view linear, truncate; valves lanceolate, obtuse. = *Diatoma* and *Exilaria truncata*, Grev.; *Exilaria fasciculata*, Hass.; *Synedra fasciculata*, SBD. i. p. 73, pl. 11. f. 100. Fresh water. Europe. Striæ 40 in ·001″, Sm.

S. *Arcus* (K.).—Frustules flabellate, attached to a cushion-like stipes; front view curved; valves lanceolate, with 30 marginal striæ in ·001. KB. p. 68, t. 30. f. 50; SBD. i. p. 73, f. 98. (IV. 27.) Marine. Europe and America.

2 † Frustules on an elongated, often branched, stipes.

S. *Ehrenbergii* (K.).—Frustules attenuated near the obtuse apices, terminal on a long, linear stipes. KB. p. 69, t. 11. f. 6. Fresh water. Berlin.

S. *Saxonica* (K.).—Stipes a little elongated; frustules slender; front view linear, truncate; valves narrow lanceolate. KB. p. 68, t. 15. f. 14. Salt Lake at Mansfeld. 1-330″.

S. *fulgens* (Grev., S.).—Frustules terminal on a thick, branched stipes, geminate linear, truncate; valves linear, inflated at centre and ends; striæ 36 in ·001″. SBD. i. p. 74, pl. 12. f. 103. = *Exilaria fulgens*, Grev.; *Licmophora fulgens*, KB. t. 13. f. 5. Marine. Europe and America.

S. *crystallina* (Ag., K.).—Frustules very large, on a thickish abbreviated stipes; valves linear, inflated at centre and apices; striæ distinct, 26 in ·001″. KB. p. 69, t. 16. f. 1; SBD. pl. 12. f. 101. = *Diatoma crystallina*, Ag. Marine. Europe. 1-60″ to 1-48″.

S. *superba* (K.).—Stipes somewhat elongated; valves stout, linear-lanceolate, with rounded ends; striæ very distinct, 27 in ·001″. KB. p. 69, t. 15. f. 13. SBD. i. p. 74, pl. 12. f. 102. Marine. Europe.

S. *Dalmatica* (K.).—Stipes somewhat elongated and branched; frustules large, linear, slightly and gradually attenuated at the subtruncate ends. KB. p. 69, t. 12. f. 2. Marine. Adriatic Sea. Frustules terminal on the branches. 1-240″.

S. *robusta*, n. s. — Frustules linear; valves elliptical, ends rounded. Striæ 20 in ·001″, interrupted by three equidistant longitudinal lines. ·0120″ to ·0175″. Algæ, Corsica. (VIII. 3.)

S. *gigantea* (Lobarz.).—Frustules very long, delicate, somewhat twisted, linear, truncate; valves very narrow, with dilated, obovate apices. Lobarzewsky, Linnæa, 1840, p. 276, t. 6; KSA. p. 48. Marine. Dalmatia.

7 * *Frustules connected in tablets, at length separating, and adhering by alternate angles, as in Diatoma.*

S. *rumpens* (Kütz.).—Tablets affixed; frustules very narrow linear, with tumid obtuse apices, adhering by alternate angles. KB. p. 69, t. 16. f. 6. Brackish water. German coast.

Doubtful species from Ehrenberg.

S. *australis*. — Linear, striated, with attenuated, obtuse apices in both views. ERBA. 1840; Microg. pl. 1. 1. f. 3. In siliceous schist from the Philippine Islands. 1-432″.

S. *paleacea*.—Very narrow, smooth, with subacute apices. EM. pl. 1. 1. f. 1. With the last. 1-480″.

S. *incurva*. — Linear, very narrow, flexuose, smooth, round, or equally quadrangular. ERBA. 1844, p. 272. Bermuda. 1-288″. Perhaps a Spongolithis.

S. *rostrata* (EM. pl. 9. 1. f. 4, and pl. 14. f. 44).—Fossil. France and Germany. Valves elongated, slender, linear, with contracted, conic apices, and transverse striæ.

S. elegans, Asia; *S. striata*, Asia; *S. lineata*, Asia; *S. subulata*, Africa; *S. curvata*, America.

S. *doliolus* (Wallich). — Frustules linear; valve subarcuate, pseudo-nodule absent. Striæ 30 in ·001″. ·0020″ to ·0050″. Salpæ. Indian Ocean, Atlantic. Wallich, TMS. viii. p. 48, pl. 2. f. 20.

Genus DESMOGONIUM (Ehr.).—We are unacquainted with the characters of this genus; Ehrenberg's figures of it seem to show a relation to Synedra, the tablets (not single frustules) being attached to each other by a connecting substance, end to end—an arrangement which simulates a filament.

DESMOGONIUM *Guianense*.—EM. t. 34. 5 A. f. 3. Apparently not very uncommon, since Ehrenberg gives about 50 habitats in Asia, Africa, and America. (xv. 13.) Frustules not stipitate; valves without longitudinal ridges, mostly broader than the front view.

Genus DIMEREGRAMMA (N., G.).—Frustules quadrangular, two or more together; valves scarcely broader than front view, having the transverse costæ or striæ interrupted by a smooth, longitudinal median line. The frustules are united as in Denticula or Odontidium, from which genera it is distinguished by the longitudinal median line. The structure is probably the same as in Staurosira (E.), the description of which, however, is altogether inapplicable to many of the species here assembled.

DIMEREGRAMMA *minor* (Greg.). — Front view with convex striated margins, constricted beneath the conic angles; valves narrow lanceolate, with from 18 to 20 strong costæ in ·001''. = *Denticula minor*, GDC. p. 23, pl. 2. f. 35. Marine. Scotland.

D. *capitatum* (Greg.). — Front view with convex, obscurely striated margins, constricted beneath the dilated roundish apices. = *Denticulata capitata*, Greg *l. c.* p. 22, pl. 2. f. 31. Marine. Scotland. Is larger than *D. nanum*, with rounded apices. Side view unknown.

D. *nanum* (Greg.).—Front view with convex margins, constricted beneath the conic angles; valves broad, obtusely rhomboid, with rather fine striæ. = *Denticula nana*, Greg *l. c.* p. 23, pl. 2. f. 34. Marine. Scotland. (IV. 33.)

D. *distans* (Greg.).—Front view constricted beneath the conic angles; valves broad, rhombic-lanceolate, with strong, short marginal costæ, and a lanceolate, blank median space. = *Denticula distans*, Greg *l. c.* p. 23, pl. 2. f. 36. Marine. Scotland. Is larger than *D. minor*, and its valves broader. (IV. 34.)

D. *Rhombus* = *Fragilaria*? *Rhombus*, EM. pl. 8. 1. f. 16. Fossil. Hungary. Valves broadly rhomboid, with marginal costæ, and a smooth median space.

D. *fulvum* (Greg.).—Front view elongated, with striated margins, constricted beneath the dilated apices; valves narrow lanceolate, with dilated, subcapitate apices; striæ moniliform, nearly reaching the centre. = *Denticula fulva*, GDC. p. 24, pl. 2. f. 38. Marine. Scotland.

D. *marinum* (Greg.). — Front view elongated, linear, with striated margins and slightly produced angles; valves linear, with gibbous middle, obtusely conic apices, and about 10 coarsely moniliform striæ in ·001''. = *Denticula marina*, Greg *l. c.* p. 24, pl. 2. f. 39. Marine. Scotland.

D. *mutabile* (Sm.).—Filaments elongated; valves oblong or lanceolate, with 20 marginal costæ in ·001''. = *Odontidium mutabile*, SBD. ii. p. 17, pl. 34. f. 290; *Fragilaria amphioxys*, EM. pl. 39. 3. f. 53. Fresh water. Europe.

D. *Leptoceros* (E.).—Valves rhomboid-linear, with longly attenuated, acute, straight ends, finely striated margins, and a smooth median space. = *Fragilaria Leptoceros*, ERBA. 1844, p. 82; *Odontidium Leptoceros*, KSA. p. 13. North America.

D. *sinuatum* (Thwaites).—Front view linear, truncate; valves rhomboid-lanceolate, with slightly undulated margins; striæ delicate, 52 in ·001''; costæ interrupted, 10 in ·001''. = *Denticula sinuata*, SBD. ii. p. 21, pl. 34. f. 295. Fresh water. Britain. (IV. 12.)

D. *Tabellaria* (Sm.). — Filaments fragile; valves with constricted or inflated middle, rostrate apices, and 36 delicate costæ in ·001''. = *Odontidium Tabellaria*, SBD. ii. p. 17, t. 34. f. 291. *a*, valves inflated at the middle, = *Staurosira construens*, Eh.? *β*, valves constricted at the middle. (IV. 35.)

D. *birostris* (E.).—Very minute; valves lanceolate, suddenly rostrate, acute; striæ interrupted by a median line. = *Fragilaria birostris*, ERBA. 1844, p. 342; Microg. pl. 38 A. 2. f. 8. Fossil. Germany. 1-3120''. Has nearly the characters of a Staurosira, *Eh.*

D. *informe* (S.). —Valves elliptical, with an irregular inflation at the centre, and hence subcruciform; costæ 18 in ·001.'' = *Odontidium informe*, S Annals, 1857, p. 10, pl. 1. f. 12. Fresh water. France.

D. *Harrisonii* (Sm.). —Frustules frequently adhering by their angles; valves cruciform, with rounded lobes; costæ distinct, 13 in ·001''. = *Odontidium*? *Harrisonii*, SBD. ii. p. 18, pl. 60. f. 373. Fresh water. Hull. The valves in form resemble those of a small Tetracyclus, but have interrupted costæ; the front view, too, is very different. (XVIII. 6.)

D. *pinnatum* (E.).—Valve cruciform, with angular lobes; costæ as in *D. Harrisonii.*=*Staurosira pinnata*, EM. t. 5. 2. f. 24; *Odontidium Harrisonii*, β, Roper, MJ. ii. p. 6, f. 6. Europe and America. (VIII. 4.)

D. *speciosum* (Brightwell). — Valve subcruciform or rhomboidal; angles rounded, naked; costæ short, distinct, 16 on each side. = *Odontidium speciosum*, Brightwell, JMS. vii. p. 180, pl. 9. f. 8.

Doubtful species.

D. *Surirella* = *Fragilaria Surirella*, EM. pl. 39. 3. f. 54. Frustules large, broadly linear, with rounded ends and marginal costæ.

D. *Baldjickii* (Brightwell). — Valve ovately rhomboidal; costæ about 20 on each side, distinct, reaching nearly to the ends, but leaving a linear open space down the centre. In a clay or earthy deposit from Baldjick, Mr. Norman.= *Odontidium Baldjickii*, Brightwell, *l. c.* p. 180, pl. 9. f. 10.

Genus STAUROSIRA (Eh.).—"The form of this genus is that of quadrangular Fragilariæ; it is distinguished from the much larger forms of the allied genus Amphitetras by the absence of (pseudo-) openings at the four angles."—ERBA. 1843, p. 45. The above is the only notice of this genus we have met with, the resemblance to Amphitetras is evidently very slight. From Ehrenberg's figures, Staurosira seems to contain forms allied to Odontidium and Fragilaria, which have the valve so inflated at the centre as to appear 4-lobed. This character, however, is uncertain, since Professor Smith shows that the same species has the valve sometimes inflated, and sometimes constricted at the middle.

STAUROSIRA *construens* (E.). — Very small, smooth; valves spindle-shaped, with the produced angles somewhat unequal. EM, several figures. Asia, Africa, and America. (XV. 5.) 1-600″. Compare with *Dimeregramma Tabellaria.*

S. *amphilepta* (E.).—Minute, smooth, two of the produced angles larger and more slender than the others.

S. trigongyla, Asia; *S. Epidendrium*, Chili; *S. Mexicana*, Mexico; *S. tricarinata*, Mexico.—These species (Ehrenberg's) are known to us only by name.

Genus RHAPHONEIS (E.).—Frustules simple, free or shortly stipitate: front view narrow linear; valves much broader, with transverse dotted striæ and a median longitudinal line. Marine. Rhaphoneis differs from Cocconeis and Navicula by the absence of a central nodule. The frustule has no alæ; its striæ are usually distinctly moniliform and divergent, and its median line more conspicuous than in Tryblionella. We have not thought it desirable to separate Doryphora; for it is doubtful whether Kützing's only species is even specifically distinct from some forms still retained by him in this genus.

RHAPHONEIS *Amphiceros* (Ehr.). — Valves lanceolate, about three times as long as broad, with produced, styliform apices, and fine, dotted transverse striæ. ERBA. 1844, p. 87; M. t. 18. f. 82. = *Cocconeis Amphiceros*, E. 1840; *Doryphora Amphiceros*, KB. p. 74; SBD. i. pl. 24. f. 224. Marine. Europe and America. (XIV. 21.) 1-576″. Striæ 18 to 20 in 1-1200″. Ends suddenly contracted and prolonged into a beak.

R. *Fusus* (E.).—Valves slender, linear-lanceolate, usually four times as long as broad, with styliform apices, and 17 or 18 fine, transverse, granulated striæ in 1-1200″. ERBA. 1844, p. 87. Fossil. Virginia. 1-720″. Strongly akin in habit to *Fragilaria Amphiceros*, but differs by its median suture.

R. *Leptoceros* (E.). — Valves long lanceolate, quadrangular, rhomboid, three times as long as broad, with long styliform apices and fine, granulated transverse striæ. ERBA. 1844, p. 87.=*R. Oregonica*, EM. pl. 18. f. 83. Fossil. America. 1-720″. Striæ generally 18 in 1-1200″. Has the habit of *R. Amphiceros*, but with much longer beaks.

R. *gemmifera* (E.). — Large; valves elongated lanceolate, with long gradually attenuated apices, usually three times as long as broad; striæ strongly granulated, 10 in 1-1200″. ERBA. 1844, p. 87. Fossil. Maryland. 1-300″.

R. *pretiosa* (E.). — Large; valves broadly lanceolate, rhomboid, generally twice as long as broad; apices gradually attenuated into beaks; striæ stout, granular, like series of pearls. ERBA. 1844, p. 87. Fossil. Maryland. 1-480″. Striæ 11 in 1-1200″.

R. *Rhombus* (E.). — Small; valves broadly lanceolate, rhomboid, sometimes suborbicular, scarcely longer than broad, with short rostrate apices and fine granulated striæ. ERBA. 1844, p. 87; M. pl. 33. 13. f. 19. Cuxhaven, Virginia. 1-1152″ to 1-864″. Striæ 20 to 21 in 1-1200″.

R. *scalaris* (E.). — Valves slender, acutely lanceolate, furnished with a double series of striæ and window-like crystalline spaces. ERBA. 1844, p. 271. Fossil. Bermuda deposit. Diameter 1-960″. Striæ 9 in 1-1200″.

R. *angusta* (E.). — Valves elongate lanceolate, with obtuse apices, 24 striæ in 1-1200″, and no median smooth space. ERBA. 1844, p. 364. India.

R. *lanceolata* (E.).—Valves rhomboid-lanceolate with obtuse apices, 21 striæ in 1-200″, and a linear-lanceolate median smooth space. ERBA. 1844, p. 364; M. pl. 34. 7. f. 13. India, China, and Japan.

R. *Indica* (E.). — Valves elliptic-lanceolate with obtuse apices, 15 striæ in 1-1200″, and a linear-lanceolate median space. ERBA. 1844, p. 365. India and Japan.

R. *fasciolata* (E.). — Large; valves elliptic-lanceolate, twice as long as broad, with strong, finely granulated striæ in transverse fasciæ. ERBA. 1844, p. 204; M. pl. 35 A. 22. f. 16. Antarctic Sea. Ehrenberg's figure represents the valve as elliptic, with transverse band-like series of short longitudinal striæ, alternating with smooth spaces, and interrupted by a smooth longitudinal median line. (? Lower valve of a Cocconeis.)

R. *Scutellum* (E.). — Valves elliptic, longer than broad, with 12 or 13 stout, crenulated striæ in 1-1200″. ERBA. 1844, p. 204; M. pl. 35 A. 1. f. 5. Antarctic Sea. 1-864″. (? Lower valve of a Cocconeis.)

R. *fasciata* (E.). — Microg. pl. 35 A. 9. f. 8. India. Valve elliptic, with broadly rounded ends, a median line, transverse fasciæ of longitudinal lines alternating with smooth transverse bands, and two series of marginal striæ. (? Lower valve of a Cocconeis.)

Species (Eh.) known to us only by name.

R. *setacea*, Sandwich Islands; R. *Entomon*, Asia Minor; R. *rhomboides*, Ganges; R. *Gangetica*, Ganges; R. *lævis*, India; R. *Africana*, South Africa; R. *Digitus*, Demerara.

Genus TRYBLIONELLA (S.). — "Frustules simple, free, elliptical or linear; valves plain; alæ submarginal or obsolete, canaliculi inconspicuous, parallel."—Smith. Tryblionella is another genus separated from Surirella by Professor Smith, who says that it "differs from Campylodiscus in the more elongated form of its frustules and the absence of the bend in its valves; the canaliculi are also more minute, and parallel rather than radiating. It agrees with Surirella in the presence of alæ; but these arise from the disk." Mr. Roper considers that Tryblionella is distinguished from Surirella by its fine (often obsolete), parallel transverse striæ; whereas the latter is furnished with canaliculi or costæ, which are more or less divergent.

TRYBLIONELLA *circumsuta* (B.). — Lateral view elliptic-oblong, with a faint, longitudinal median line (indistinct or obsolete), parallel transverse striæ, and marginal gland-like dots; alæ very short. = *Surirella circumsuta*, Bailey, MO. pl. 2. f. 36; *T. Scutellum*, SBD. i. p. 35, pl. 10. f. 74. Marine. America, Britain. Professor Bailey describes it as having a minutely granulate surface, and a scarcely perceptible median constriction.

T. *gracilis* (S.).—Front view linear, with attenuate extremities and truncate apices; lateral view linear-acuminate; costæ parallel, extending to median line; alæ distinct. SBD. i. p. 35, pl. 10. f. 75. Fresh and brackish waters. Lewes. (IV. 36.)

T. *navicularis* (Bréb.). — Front view oblong, with truncate, slightly winged ends; lateral view elliptic-acuminate; costæ distinct, marginal; alæ conspicuous. = *Surirella navicularis*, Bréb. in KSA. p. 36; *T. marginata*, SBD. i. p. 35, pl. 10. f. 76. Fresh and brackish waters. France; England.

T. *acuminata* (S.). — Lateral view linear, with attenuated ends and delicate, interrupted transverse striæ; alæ obsolete; canaliculi obscure. SBD. i. p. 36, pl. 10. f. 77. Marine and brackish waters. Britain. ·0012″ to ·0021″. Striæ 31 in ·001″. (IV. 37.)

T. *angustata* (S.).—Resembles *T. acuminata*; but its striæ are continuous. SBD.

p. 36, pl. 30. f. 262. Fresh water. England. ·0021″ to ·0040″. Striæ 36 in ·001″.

T. *levidensis* (S.).—Lateral view linear, with subacute extremities; costæ very distinct, parallel, extending to the central line. SBD. ii. p. 89. Brackish water. Cork City Park.

T. *punctata* (S.).—Lateral view elliptic, with acuminate ends and parallel, transverse, moniliform striæ; canaliculi obsolete. SBD. i. p. 36, pl. 30. f. 261. Marine. Sussex.

T. *constricta* (Greg.).—Lateral view panduriform, with apiculate ends and numerous, delicate, diagonal, punctated striæ; costa obsolete. Greg. in MJ. iii. pl. 4. f. 13. Marine. Britain. "Its form is that of *Cymatopleura Solea*, but it is very much smaller."—Greg.

T. *apiculata* (Greg.).—Narrow, linear, slightly constricted in the middle, with apiculate extremities and about 45 fine but distinct, transverse, dotted striæ in ·001″. Greg. in MJ. v. p. 79, pl. 1. f. 43. Scotland. ·0015″ to ·0017″. Keel often strongly marked.

Genus CYMATOPLEURA (S.).—Frustules free, in front view linear, with undulated margins; laterally broader, and marked with transverse bars. Aquatic. This genus, instituted by Smith, is very distinct, and may be recognized by the lateral surfaces projecting in the front view in an undulated manner, the central portion being separated from the undulations by a marginal row of dots. The lateral view is usually very much broader than the front, which often renders it difficult to obtain a satisfactory sight of the latter. The lateral surfaces, however, sufficiently identify the genus, as the broad, transverse, shade-like bands or bars which correspond with the undulations are characteristic. The striæ are generally obscure or obsolete, and the median longitudinal line is less evident than in Surirella; the margin is usually furnished with conspicuous gland-like dots. "The undulations of the valves separate Cymatopleura from Tryblionella and Surirella; the absence of alæ and canaliculi are further characters which leave no room for hesitation as to its distinctness." (Smith.)

CYMATOPLEURA *Solea* (Bréb., S.).—Frustule elongate; laterally panduriform, with more or less attenuated ends, sometimes apiculated; striæ delicate, 8 in 1-1200″. SBD. i. p. 36, f. 78. = *Surirella Solea*, Bréb. in KSA. p. 34; *S. Librile*, E.; *Sphinctocystis librilis*, Hass BA. p. 102, 3. Var. *β*, ends apiculated, = *C. apiculata*, S. *l. c.* p. 37, f. 79. Common, Asia, Africa, America, Europe. (IX. 155; XVI. 9.) Frustules, in both views, many times as long as broad; undulations six. The ends, in the lateral view are always attenuated; but their apices vary, and are sometimes obtuse, sometimes apiculate; and therefore we concur with M. de Brébisson in uniting *C. apiculata*, Smith, with this species.

C. *heterocyma* (Nägeli). — Lateral view panduriform, with 16 marginal striæ in 1-1200″; front view broadly linear, twice undulately twisted, with six marginal folds. = *Surirella heterocyma*, KSA. p. 889. Switzerland. 1-240″.

C. *elliptica* (Bréb., S.).—Lateral view elliptic, with three to five transverse bars; ends, in general, slightly attenuated. SBD. p. 37, pl. 10. f. 80. = *Surirella oophæna*, E. (according to Kützing); *S. undulata*, EM.; *S. undata*, EM.; *S. plicata*, EM. pl. 15 A. f. 50, 51?; *S. Kützingii*, Perty, Diat. p. 201, t. 17. f. 2. Aquatic. Asia, Africa, America, Europe. (IX. 149; XVI. 7, 8.) Professor Kützing describes the frustules as ovate; but we have always found them elliptic. Undulations three to five; lateral surfaces obscurely striated and furnished with marginal gland-like dots. We have referred the *Surirella plicata*, E., to this species, because of its habitat, although its figure in the 'Microgeologie' agrees better with that of *C. Hibernica*.

C. *Hibernica* (S.). — Lateral view broadly elliptic, with produced ends; striæ obscure. SBD. i. p. 37, pl. 10. f. 81. Ireland, France. Undulations about three; length 1-370″ to 1-220″; breadth two-thirds the length.

C. *Regula* (E.).—Lateral view linear, with cuneate ends and six transverse bars. = *Surirella Regula*, KB. t. 28. f. 30.; *C. parallela*, Smith, BD. pl. 30. f. 263. Mexico, France, England. Habit and size of *C. Solea*, but not panduriform; pinnules 10 in 1-1200″, nearly obsolete.

C. *Ovum* (Nägeli). — Lateral view broadly oval, with 8 marginal striæ in 1-1200″; front view broadly linear, straight; margin with five marginal folds. = *Surirella Ovum*, Nägeli in KSA. p. 889. Switzerland. 1-360″ to 1-280″. The characters given are insufficient to distinguish it from *C. elliptica.*

Genus SURIRELLA (Turp., E., S.).—Frustules simple, free; margin striated; lateral surfaces broader than the front view, with a smooth median longitudinal line; "margins produced into alæ, canaliculi distinct, usually parallel" (Smith). Surirella thus limited by Professor Smith becomes a much more natural genus than it was constituted by preceding authors: he says, "It is well distinguished from Tryblionella by the prominency of its alæ, the distinctness of its canaliculi, and the usually cuneate form of its frustules; with no other is it at all likely to be confounded."

* *Frustules panduriform.*

SURIRELLA *constricta* (E.).—Large, oblong, in lateral view panduriform, with a median line and intramarginal crenations. EM. pl. 14. f. 37. *Denticula constricta*, KB. t. 3. f. 62?. Aquatic. Berlin. (XIII. 3.) Ehrenberg's figure in the 'Microgeologie' seems a true species of this genus; and different as is that of *Denticula constricta* in Kützing's work, yet, as it was copied from a figure given by Ehrenberg in an earlier work, the differences are probably due to the imperfect representation.

S. *Smithii* (K.).—Front view broadly linear, with truncate ends and rounded angles; lateral view panduriform, with attenuated ends; costæ delicate, reaching the median line, which is often inflated. = *S. constricta*, SBD. i. p. 31, pl. 8. f. 59. Brackish water. England. Alæ conspicuous, enclosing an oblong space. 1-300″. The shape, in front view, resembles that of *S. biseriata*, but the costæ are much finer.

S. *Antarctica*, EM. pl. 35 A. 2. f. 20. Antarctic Sea. We have seen no description of this species. Ehrenberg's figure shows the lateral view panduriform, with rounded ends and strongly marked striæ, which nearly reach the median line.

S. *didyma* (K.).—Oblong, with truncate ends, constricted middle and punctated margins. KB. p. 60, t. 3. f. 67. Submarine waters. Isle of Wangeroog. 1-600″. This appears to us a doubtful species of Surirella; for Kützing's figure seems to represent a frustule constricted in the front view, as it shows a linear median portion truncated at its ends.

S. *panduriformis* (Rab.).—Resembles *S. didyma*, but is stouter, and its marginal dots appear stalked. Rab. p. 29, t. 3. f. 9. Italy.

2* *Lateral view lanceolate or oblong, with its ends usually equally attenuated.*

S. *Craticula* (E.).—Lanceolate; costæ few, reaching the median line, central ones divergent. SBD. pl. 9. f. 67. Aquatic. Australia, Asia, Africa, America, Britain. (XII. 19, 20.) Costæ 7 in 1-1200″. 1-288″. The central costæ are usually more distant, leaving a transverse smooth space bisected by the median line. Smaller than *S. biseriata*; its costæ fewer and more divergent.

S. *megaloptera*, EM. pl. 33. 1. f. 17. Egypt. The figure resembles that of *S. Craticula*; but the costæ are all parallel, and the median line, as well as costæ, are interrupted at the centre by a broad, transverse band.

S. *biseriata* (Bréb.).—Front view quadrilateral, with conspicuous alæ; lateral view oblong-lanceolate, with broad costæ, which usually reach the median line. SBD. i. p. 30, pl. 8. f. 57. = *S. bifrons*, E. Common. (XVI. 20–26.) Differs from *S. splendida* by its parallel sides in front view. Its angles are rounded, and the alæ enclose an oblong space; its costæ are conspicuous in both views. 1-210″ to 1-100″. Striæ $3\frac{1}{2}$ in 1-1200″.

S. *decora* (E.).—Large, linear-lanceolate, with equal, attenuated ends and four or five marginal costæ in 1-200″. EM. pl. 5. 3. f. 23. America, Ireland. Ehrenberg's figures are oblong lanceolate, one of them constricted.

S. *reflexa* (E.).—Lanceolate, with nearly equal, slightly reflexed, subacute ends, a distinct median suture, and strong, short striæ, in the middle three or four in 1-1152″. EM. pl. 33. 11. f. 13. Fossil. Connecticut.

S. *leptoptera* (E.).—Lanceolate, with nearly equal, acute ends, a distinct, dilated median suture, and dense transverse striæ, which in the middle are 6 in 1-1152″. KSA. p. 36. Fossil. Oregon. A specimen 1-456″ long presented 21 striæ.

S. *Oregonica* (E.).—Spathulate, with unequal, subacute ends, a distinct, dilated median suture, and strong striæ, which in the middle are four or five in

1-1152″. EM. pl. 33. 12. f. 27. Fossil. Oregon. A specimen 1-336″ long presented 19 striæ. Ehrenberg's figure is elliptic-lanceolate, with a median line dilated at the centre into a large oval form; the striæ short and externally terminating in gland-like dots.

S. *turgida* (S.). — Elliptic-lanceolate, with tapering, sometimes contracted ends and obtuse apices; costæ few (4 in ·001″), conspicuous, separated by a median lanceolate space. SBD. i. p. 31, pl. 8. f. 59. = *S. Caledonica*, EM. pl. 15 A. f. 47? Aquatic. Ireland. Distinguished by its ventricose centre.

S. *oblonga* (E.). — Oblong-lanceolate, with obtuse ends, near the margin sinuoso-dentate. KSA. p. 35. Aquatic. Africa; America; Mourne deposit, Ireland. Ehrenberg's figures in the 'Microgeologie' differ very much in form, but all have the costæ confined to the margin.

S. *Breuteliana* (Rab.).—Linear-elliptic, with rounded ends, five transverse costæ on each side, connected at inner ends by an undulated line, and leaving a longitudinal median space with waved margins. Rab D. p. 29. t. 3. f. 13. Aquatic. St. Kitts.

S. *crenulata* (E.).—Small, elliptic-lanceolate, with crenulate margins, subacute, nearly equal ends, and a distinct median line; eleven crenules in 1-1152″, extending into striæ, which do not reach the centre. EM. pl. 33. f. 23. Fossil, United States. D. 1080″.

S. *microcora* (E.). — Minute, oblong-lanceolate, with somewhat acute apices, and marked near the margin with ten delicate dentations in 1-1200″. EA. p. 136, t. 2. 1. f. 34; KB. t. 29. f. 15. Asia, Africa, America.

S. *lepida* (E.). — Slender, linear-lanceolate, one end obtuse, the other a little more attenuated and subacute; striæ nine or ten in 1-1152″; the median line distinctly flexuose. ERBA. 1844, p. 272; KSA. p. 36. Kurdistan. 1-768″.

S. *tenella* (K.). — Oblong-lanceolate, with rounded, obtuse apices, and five, rather lax transverse striæ in 1-1200″; front view oblong, almost rectangular, with obtuse angles. KSA. p. 37. Aquatic. Prussia.

S. *obtusangula* (Rab.). — Small, lanceolate, with cuneate, attenuated, obtuse ends, and six short costæ in 1-1200″; front view oblong, broadly rounded. Rab. p. 29, pl. 3. f. 27. Aquatic. Germany.

S. *Amphioxys* (S.). — Elliptic-lanceolate, with subacute extremities, and nine costæ in ·001″; front view linear. SBD. ii. p. 88. Haverfordwest.

S. *angusta* (K.).—Minute, linear, with cuneate ends, rather obtuse apices, and 11 costæ in 1-1200″; alæ obsolete; front view linear, truncate. KB. t. 30. f. 52; SBD. pl. 31. f. 260. Aquatic. Europe; Lewes.

S. *apiculata* (S.).—"Elliptical, ovate, smaller extremity produced into a linear, truncate apiculum; costæ 15 in ·001″." SBD. ii. p. 88. Aquatic. England. Length of frustule ·0008″ to ·0012″. "A close ally, if not a variety, of *S. angusta*."

S. *linearis* (S.).—Minute, linear, with cuneate ends, distinct transverse costæ, and a narrow median line. SBD. i. pl. 8. f. 58a′. = *S. acuminata* (Bréb. MS.). Aquatic. England, France. Var. *β*, slightly constricted at the middle, S. p. 8. f. 58a″. In the front view this species resembles a small form of *S. biseriata*.

3* *Lateral view with one end broadly rounded, the other smaller (ovate or ovate-oblong); front view usually cuneate.*

S. *robusta* (E.). — Large, elongated; ovate-oblong, with two stout costæ (which do not reach the centre) in 1-1200″. EM. pl. 15 A. f. 43. *S. nobilis*, SBD. pl. 8. f. 63. Aquatic. Fossil. Finland; Britain. 1-216″ to 1-120″. Distinguished by its large size, elongated, slightly tapering form, and large intramarginal crenations.

S. *procera*, EM. pl. 14. f. 33. Berlin. The figure represents a large species, slightly broader at one end, with large intramarginal crenations as in *S. robusta*, but the strong transverse costæ are separated only by a narrow median band.

S. *splendida* (E., K.). — Front view cuneate, with rounded angles and prolonged costæ; lateral view ovate-oblong with conspicuous, diverging costæ which reach the median line; alæ distinct. EM. t. 15 A. f. 44; SBD. i. pl. 8. f. 62. Aquatic. Common, both living and fossil. (IX. 150–152.) Var. *β. linearis*, smaller, lateral view narrow, slightly tapering, = *S. linearis*, SBD. i. pl. 8. f. 58 *a*. 1-210″ to 1-100″. As the front view has rounded angles, it is not unlike the lateral one in outline, but the ends are broader. Two or three times as long as broad.

S. *tenera* (Greg.). — Narrow linear-oblong, with one end more tapering than the other; costæ distinct, reaching the median line. Greg MJ. iv. p. 10, pl. 1. f. 38. Scotland. It is smaller than *S.*

splendida, and its alæ are less conspicuous; but it resembles that species in form, and we doubt whether it be distinct.

S. *striatula* (Turp.).—Front view broad cuneate, with rounded angles and short costæ; lateral view ovate, with distant, curved costæ, which reach the median line; alæ small. SBD. i. pl. 9. f. 64. Common. Resembles *S. splendida*, but is shorter in proportion to its breadth. In the front view the central portion is broader, the ends more truncate, the costæ shorter, and the alæ less conspicuous. Lateral view faintly striated; striæ 8 to 13 in 1-1200″.

S. *limosa* (Bai. MS.?).—Broadly ovate acuminate, faintly punctato-striate; canaliculi short and indistinct, not reaching more than 1-6″ across the valve; length ·0073″, breadth ·0035″; striæ indistinct, 22 in ·001. New Zealand, Hudson River, New York, Thames mud. Bri JMS. vii. p. 179, pl. 9. f. 5.

S. *brevis* (E.).—Short; form and size of *S. striatula*, but with 16 finer striæ in 1-1200″. ERBA. 1844, p. 272; KSA. p. 39. Kurdistan. 1-912″.

S. *Testudo* (E.).—Large, ovate, obtuse, with 12 slender striæ in its length, which is 1-288″. E *l. c.* 1840, p. 24; KSA. p. 39. Marine.

S. *Gemma* (E.).—Front view narrow cuneate; lateral view broader, ovate-elliptic, faintly striated between the delicate, unequally distant costæ, which reach the median line; alæ inconspicuous. KB. t. 7. f. 9; SBD. i. pl. 9. f. 65. Common in marine marshes. (XII. 2-4.) Distinguished from *S. striatula* by its much finer costæ and less conspicuous alæ, which in the lateral view generally coincide with the margins. Sometimes nearly elliptic. We have rarely seen it so narrow as Professor Smith's figure represents it.

S. *lævigata* (E.).—Elongated, smooth, with subequal, obtuse ends, a distinct median suture, and two longitudinal lateral lines. KSA. p. 36; EM. t. 33. 14. f. 24. Fossil. United States. 1-168″. Ehrenberg's figure in the 'Microgeologie' is ovate, with a median line, lax intramarginal crenations, and very short costæ.

S. *Guatimalensis*, EM. pl. 33. 6. f. 7. America. Figure broadly ovate, with both ends much rounded, and minute intramarginal crenations, without median line or costæ.

S. *ichthyocephala* (Rab.). — Large, ovate-oblong, with rounded ends, three broad, flexuose costæ in 1-1200″ and a broad linear median band. Rab D. p. 30, pl. 10, Supp. f. 6. Italy. The figure shows the costæ curved, except the middle one, which is broader and straight.

S. *cordata* (E.). — Ovate-subcordate, with four lax striæ in 1-1152″, contiguous in the median line. ERBA. 1845, p. 272; KSA. p. 39. Fossil. Georgia.

S. *prætexta* (E.). — Long ovate, more than twice as long as broad, with five rather lax striæ in 1-1252″, towards the middle broadly interrupted and not contiguous in the median line, hence forming four series with a broad linear median space and two smooth lateral ones. Maritime. India. ERBA. 1845, p. 365; KSA. p. 38.

S. *euglypta* (E.).—Small, ovate-oblong, with seven striæ in 1-1200″, which do not reach the centre; front view cuneate, with rounded angles at larger end. EA. p. 136, t. 3. 5. f. 2. 4; KB. t. 28. f. 27. Asia, Africa, America.

S. *uninervis* (E.).—Small, ovate, half as long again as broad; costæ reticulated at the margin, contiguous at the slender median line, 7 in 1-1152″. KSA. p. 38. Maritime. India, Africa.

S. *Folium* (E.). — Ovate, turgid and obtuse, slightly compressed, with 24 fine striæ in 1-1150″. Fossil. Barbadoes. 1-540″.

S. *Crumena* (Bréb.).—Small, orbicular ovate, with 7 or 8 evident marginal striæ in 1-1200″. KSA. p. 38. Aquatic. France, Britain. Its suborbicular form in lateral view distinguishes it from every other species except *S. Brightwellii*.

S. *Brightwellii* (S.). — Small, suborbicular, with one end subacute; costæ distinct, marginal, 10 in ·001″; alæ inconspicuous. SBD. i. p. 33, pl. 9. f. 69. Britain. According to Professor Smith, this species is distinguished from *S. Crumena* by its coarser and more prominent costæ and distinct striæ; *S. Crumena* is also smaller and more orbicular.

S. *ovalis* (Bréb.).—Small, ovate-elliptic, with 8 marginal costæ in 1-1200″, and one end more attenuated than the other; alæ inconspicuous. KSA. p. 33; SBD. pl. 9. f. 68. Aquatic. France, Britain. Front view oblong-cuneate, truncate. 1-360″ to 1-280″. Margin with very short, teeth-like costæ. The larger end in lateral view is less rounded than in the allied species.

S. *ovata* (K.).—Minute ovate, or ovate-elliptic, with 7 to 9 delicate, very short, marginal costæ in 1-1200″; alæ inconspicuous. KB. pl. 7. f. 1–4; SBD. pl. 9. f. 70. Europe, America. Front view broadly cuneate, truncate. 1-1200″ to 1-560.″

S. *minuta* (Bréb.). — Minute, ovate-elliptic, with inconspicuous alæ and 14 marginal costæ in ·001″. SBD. i. p. 34, pl. 9. f. 73. France, England. ·0005″ to ·0009″. Kützing unites this form with *S. ovata*; but M. de Brébisson informs us that he is able to distinguish the two species when *in situ* at the first glance; that the stratum of this species is black and very mobile, whilst that of *S. ovata* is brown, and adheres more firmly to the soil.

S. *salina* (S.).—Minute, ovate-oblong, with numerous minute marginal costæ and obsolete alæ. SBD. i. p. 34, pl. 9. f. 71. Marine or brackish waters. England. Front view wedge-shaped.

S. *subsalsa* (S.). — Minute, ovate-lanceolate, with 8 distinct costæ and 30 striæ in 1-1200″; alæ conspicuous. SBD. i. p. 34, pl. 31. f. 259. = *S. pygmæa*, EM. pl. 35 A 8. f. 4? Fresh or brackish waters. England.

S. *pinnata* (S.). — Minute, narrow, ovate-oblong or somewhat clavate, with large, subdistant marginal costæ; alæ obsolete. SBD. i. p. 34, pl. 9. f. 72. Aquatic. Lewes. Front view narrow cuneate.

4 * *Lateral view with broadly rounded, rarely unequal, ends.*

S. *Lamella* (E.). — Large, narrow elliptic, with nearly equal, broadly rounded ends; intramarginal striæ and granulose median area; front view narrow linear, truncated. EM. pl. 15 A. f. 49. Lough Mourne deposit. 1-216″ to 1-180″. Ehrenberg's figure has no median line.

S. *Liosoma* (E.).—Narrow elliptic, with broadly rounded ends, a narrow margin of fine striæ, and a smooth median area with a median longitudinal line. EM. pl. 33. 14. f. 25. Maritime. India. Three times as long as broad.

S. *Patella* (K.).—Elliptic-oblong, with equal, rounded ends, and four or five marginal striæ in 1-1200″. KB. t. 7. f. 5. Fossil at Franzensbad.

S. *Peruviana* (E.). — Large, elliptic-oblong, with equal, rounded ends, and about 12 very short, obsolete, marginal costæ in 1-1200″. KB. t. 29. f. 72. Peru.

S. *amphiamblya*, EM. pl. 14. f. 34. Berlin. The figure shows a large elliptic form with equal, rounded ends, intramarginal crenations, and strong, parallel, transverse costæ, which do not quite reach the median line.

S. *Mississipica*, EM. pl. 35 A. 8. f. 5. America. Ehrenberg's figure is large, eilliptic-oblong, with equal, rounded ends, and parallel transverse costæ, separated by a narrow linear, longitudinal median band.

5 * *Lateral view with rounded ends; costæ with dilated outer portion, and median space finely striated.*

S. *fastuosa* (E.). — Elliptic, with rounded ends, rather distant costæ, inflated towards the margin, and a transversely striated, lanceolate median space. Greg MJ. iii. p. 30, pl. 4. f. 41. Marine. Common. Europe, Asia, Africa, America. Distinguished from all the preceding species by its inflated costæ resembling stalked flowers, and by the striated median space, which is very variable in breadth. Differs much in size, and is sometimes nearly orbicular; we have never seen it ovate, as described by Professor Smith.

S. *lata* (S.). — Large, broadly linear-elliptic or somewhat panduriform, with broadly rounded ends, a transversely striated median area, and distant costæ externally dilated. SBD. i. p. 31, pl. 9. f. 61. = *Campylodiscus productus*, Johnston. Marine. Not uncommon. England. Differs from *S. fastuosa* in its form, and usually in its larger size; but the markings are similar in both. As Professor Gregory finds intermediate states, they may be, as he supposes, mere varieties.

S. *eximia* (Grev.). — Linear-oblong with rounded ends, about 18 delicate costæ on each side, reaching the narrow linear-lanceolate, transversely striated median space. Grev MJ. v. p. 10, pl. 3. f. 6. Marine. West Indies. This extremely delicate and hyaline Diatom, Dr. Greville informs us, approaches *S. lata* in form, slight constriction, and a striated central space, but differs in every other respect. The costæ equidistant, and as fine as those of *S. Gemma*; alæ narrow, but conspicuous.

Doubtful or undescribed Species.

S.? *Cocconeis*, EM. pl. 35 A. 8. f. 3. Marine. India, Africa. This species, according to the figure, is small, elliptic, with obtuse ends, and parallel transverse costæ separated by a smooth, narrow-lanceolate median space.

S. *Jenneri* (Hassall). — Front view linear, with rounded ends, and distant, short, teeth-like marginal costæ. Hass. Br. Algæ, p. 439, pl. 102. f. 15. Aquatic. Sussex. Dr. Hassall describes it as a very distinct species, having no relation with *S. biseriata*.

S. *ambigua* (K.). — Broadly oblong, with truncated ends, and 4 straight, obsolete, rather broad transverse striæ in 1-1200″. KB. t. 5. f. 17. Stagnant waters, Switzerland. 1-264″. Kützing's figure apparently represents the front view, and is broadly linear, with obscure transverse costæ, leaving a narrow median portion.

S. *lævis* (K.). — Cylindrical, elliptic-lanceolate, somewhat obtuse, very smooth and hyaline. KSA. p. 36. Marine. France. 1-1080″.

S. *attenuata* (Näg.). — Smooth, linear-lanceolate, with gradually attenuated apices. KSA. p. 889. Switzerland. 1-240″. Perhaps a Tryblionella?

S.? *ornata* (K.). — Elongate, pestle-shaped, truncate at each end, with obtuse angles, longitudinally dividuate, and ornamented with minute puncta disposed in decussating lines. KB. t. 3. f. 54. Marine. Genoa. Length 1-280″; breadth 1-960″. Kützing's figure is linear-oblong with truncate ends, and seems to represent the front view, in which the striated lateral portions approach so closely at the centre that the smooth median portion is visible only near the ends. Surely this is not a Surirella?

S.? *Amphibola* (E.). — Broadly linear, with cuneate, subacute ends, and 15 striæ in 1-200″; front view with obtuse ends. ERBA. 1854, p. 271. Kurdistan. 1-324″. Has the general form of *Tryblionella Regula*. Ehrenberg remarks that he is not sure to what genus this belongs; he has sometimes fancied there was an umbilicus, as in Pinnularia, but its equal transverse striæ on each side render its form singular.

S. *Sicula* (E.). — Smooth, broadly navicular, with subacute ends and longitudinal marginal lines. EM. pl. 22. f. 58. Fossil. Sicily. 1-528″.

S. *liolepta* (E.). — Styliform, four times as long as broad, with obtuse ends and no median line; the narrow margin finely striated. KSA. p. 36. Maritime. India. 1-360″.

S.? *linea* (E.). — Bacillar, stout, one side cuneate at each end, the other rounded, finely transversely striated throughout. ERBA. 1843, p. 271. Netherlands. 1-240″.

S. *Stylus* (E.). — Large, styliform and narrow, quadrangular; one end more obtuse than the other, but neither acute; costa 54 in 1-144″. ERBA. 1843, p. 271. Near Weimar. 1-144″.

S. *rhopala*, EM. pl. 33. 1. f. 19. Egypt. Ehrenberg's figures show the front view large, longly cuneate with rounded ends, and numerous fine transverse striæ at each side, separated by a narrow smooth median portion with two puncta at each end.

S. *aspera* (E.). — Large, with four or five loosely disposed costæ in 1-1152″, with rough crests. KSA. p. 39. Volcanic earth, Hochsimmer on the Rhine. This species, named from a fragment, Ehrenberg states is perhaps a Campylodiscus.

S. *Australis* (E.). — A fragment of a linear species with six, straight transverse striæ in 1-1200″. Africa. Another species constituted by Ehrenberg's objectionable practice of naming isolated fragments.

S.? *lamprophylla* (E.), *S. Uralensis* (E.), Ural Mountains; *S. Sibirica* (E.), Siberia; *S.? curvula* (E.), India, Mexico; *S. Stella* (E.), Maritime: India, Africa; *S. Nicobarica* (E.), Nicobar; *S. compta* (E.), Egypt; *S. Zambeze* (E.), River Zambeze; *S. Platalea* (E.), Senegal; *S. Caffra* (E.), *S. Capensis* (E.), *S. clathrata* (E.), Cape of Good Hope; *S. Falklandica* (E.), *S. Meluinensis* (E.), *S. Insularum* (E.), Falkland Islands; *S. Araucania* (E.), Araucania; *S. amphicentra* (E.), *S. holosticha* (E.), *S. insecta* (E.), *S. leptotera* (E.), *S. Polyodon* (E.), Mexico.

Genus CAMPYLODISCUS (E., Men.). — Valves equidistant, frustules solitary, disciform; disk tortuous or saddle-shaped, rotundato-elliptic, costate, costæ mostly radiate. Campylodiscus has the lateral surfaces still more developed than they are in the Melosireæ, whilst the central or interstitial portion is reduced to a narrow ring, — a circumstance which renders it very difficult to obtain a satisfactory front view. In these respects it approaches the Coscinodisceæ. Kützing referred to Surirella several species now placed in this genus. Meneghini suggested their removal to Campylodiscus, in these terms — "One really is at a loss to find the motive that could induce Kützing to separate this generically from Campylodiscus;" and Professor Smith has, we consider judiciously, adopted that suggestion. "The species included under this genus may all be recognized by the characteristic bend or contortion of their surfaces."—Sm. Cocconeis differs in its small size and central nodule.

* *Disc circular, or nearly so, with a single series of marginal costæ.*

† Costæ all radiant, forming a marginal circle.

CAMPYLODISCUS *Horologium* (Williamson).—Disc nearly flat, with a marginal circle of numerous (about 50) equal, radiating costæ, having a circle of close, very short and fine striæ at its inner, and another at its outer edge, and enclosing a large, central, orbicular, smooth space. SBD. pl. 6. f. 51. Marine. Scotland. The costæ are proportionally shorter in this large species than in most others, and occupy about one-third of the radius.

C. *limbatus* (Bréb.).—Disc with a marginal circle of short costæ, continued by an inner fainter circle of moniliform lines, gradually lost in an indefinite, smooth central space. BD. p. 12. f. 1; GDC. p. 32, pl. 3. f. 55. Marine. France, Scotland. "Distinguished from *C. Horologium* by its finer costæ and granulated disc," Bréb. "Costæ broad, transversely sulcate, so as to appear on close inspection almost moniliform. Within this marginal band is another fainter band, which looks almost like the reflection in a mirror of the first, except that the bars are more directly moniliform," Greg. This species might be placed with almost equal propriety in the section with double series of costæ.

C. *imperialis* (Grev.).—Costæ 3 in ·001″, forming a magnificent band, accompanied at base by short bifid segments; central area broadly elliptical, furnished with narrow, transverse, moniliform striæ, interrupted by a median blank line. Gr TMS. viii. p. 30, pl. 1. f. 3. New Providence. In general appearance resembles *C. limbatus*, Bréb. but differs materially from that Diatom on a closer examination. Grev.

C. *Kittonianus* (Gr.).—Costæ elongated, transversely striated for two-thirds of their length. Gr TMS. viii. p. 32, pl. 1. f. 7. West Indies. Central space furnished with a median bar, as in *C. notatus*, only less conspicuous, Grev.

C. *stellatus* (Gr.).—Valve orbicular, with a narrow marginal band of close, short costæ, an inner circle of dotted lines, and a central space marked with irregular radiating lines. Gr MJ. vii. p. 157, pl. 7. f. 3. Californian guano. Costæ 10 in ·001″.

C. *radiosus* (E.).—Disc subcircular, small, with smooth or obscurely punctate centre, and border of about seventy closely-set, radiating costæ. KSA. t. 28. f. 12. Fossil. Vera Cruz. Upper Peruvian guano. We have noticed a Campylodiscus in Bolivian guano, and supposed it to be this species. The costæ are numerous, radiating, and unequal, enclosing a quadrilateral, obsoletely punctate central space, divided by a median hyaline line, and having at its angles 3–4 converging costæ.

C. *vulcanius* (E.).—Disc large, suborbicular, flexuose, with about 42 marginal rays, and smooth centre. KSA. p. 33. Peru.

C. *bicruciatus* (Greg.).—Disc circular, with a square median space occupied by crossed striæ, and prolonged to margin by four pairs of tapering, transversely striate processes in a crucial manner, each interval with four strong radiant costæ. Greg MT. v. p. 78, pl. 1. f. 42. Marine. Glenshira, Scotland. A very peculiar species, but difficult to describe. The square centre is lattice-like, and itself obscurely subdivided into smaller quadrate portions; from it proceed to the margin, in a crucial manner, four pairs of conical prolongations; the intervals between the pairs are occupied by strong rays, which, together with the striated prolongations, are connected within the margin in a scolloped manner.

2 † Disc more or less evidently divided into lateral portions by a median line or band; costæ imperfectly radiant.

C. *Hibernicus* (E.).—Disc tortuous, with numerous (30 to 40) continuous, imperfectly-radiant costæ, enclosing an irregularly shaped, minutely punctated central space. EM. pl. 15 A. f. 9. = *C. costatus*, SBD. i. pl. 6. f. 52. Aquatic. Britain. (IV. 38.) The costæ are loosely disposed (4 in 1-1152″), slightly rough from minute granules, and extend in length about half the radius. Their radiant arrangement is somewhat imperfect, from the convergence of two or more at each end. Mr. Norman has gathered this species very pure near Hull.

C. *Noricus* (E.).—Disc suborbicular,

tortuous, gradually smooth in the centre; costæ numerous, continuous, their crest acute. KSA. p. 33. Aquatic. Asia; Salzberg. Fossil at San Fiore. Rays 7 in 1-1152". D. 432".

C. *Kützingii* (B.).—Disc saddle-shaped, broadly margined, marked with about 50 transverse, continuous, curved sulci. B. in Proc. Acad. Phil. 1853. Philippine Islands.

C. *Ralfsii* (S.).—Disc small, subcircular, bent; costæ transverse, reaching the median line. SBD. i. p. 30, pl. 30. f. 257. Marine. Britain. The costæ of one side are divided from those of the other by a longitudinal median line.

C. *Normanicus* (Gr.).—Costæ 3 to 4 in ·001", imperfectly radiant, passing across a linear-oblong central depression to the narrow median blank line. Gr TMS. viii. p. 29, pl. 1. f. 1. West Indies.

C. *notatus* (Gr.).—Costæ numerous, about 12 in ·001", in length more than half the radius; central space oval, with a median thick bar dilated at each end. Gr TMS. viii. p. 31, pl. 1. f. 4. Shell-cleanings. Distinguished by the markings of the centre, which Mr. Norman aptly compares to the figure of a dumb-bell, Gr.

C. *decorus* (Bréb.).—Disc circular, bent, with a simple series of long, arcuate costæ, and a smooth, narrow-lanceolate median space. BDC. p. 13. f. 2. = *C. Ralfsii?* GDC. p. 30, pl. 3. f. 52. Marine. France, Britain. "This species is very elegant. Its costæ are, with the exception of one or two central, all curved towards the ends," Bréb. The following remarks are from Dr. Gregory's paper:—"I have referred it to *C. Ralfsii*, S., although it is much larger than the form figured by him, and although there are other differences. Thus in *C. Ralfsii* the canaliculi reach the median line, and the row of heads or expansions lie some distance from the margin. But these differences cannot be regarded as specific."

C. *angularis* (Greg.).—Disc suborbicular; costæ very numerous (160 or more) and unequal, imperfectly radiant, forming a simple marginal band, and divided into two sets by prolongations of the large, oval central smooth space. GDC. p. 30, t. 3. f. 53. Loch Fine, Scotland. Named from the angular bending back of the valves. The costæ are longest at the middle of each side; and, as in *C. decorus*, all except the central ones are curved, with the concavity towards the ends, and become also gradually smaller on approaching them. "A true median line is visible, but is very delicate. . . . . The surface of the valve, both above and below—that is, near both ends of the median line—is suddenly bent back, so as to form an angle with the rest of the valve. On the surface thus bent, short lines appear between the costæ," Greg. Distinguished from *C. decorus* by its more numerous costæ, oval central space, and extensions of the latter separating the costæ into two sets.

C. *Hodgsonii* (S.).—Disc subcircular, bent, with a marginal series of very numerous (100 or upwards) imperfectly-radiating costæ; the central space with transverse rows of dots divided by a narrow median smooth line. SBD. i. p. 29, pl. 6. f. 53. Marine. Britain. "The smooth median line is formed by a ridge and two continuous furrows passing across the valve," Smith. The costæ near the ends converge. Mr. Roper finds the dots vary greatly in number, distinctness, and arrangement, especially in the larger specimens, and on this account considers *C. eximius* not distinct from it.

C. *concinnus* (Grev.).—Costæ 5 in ·001", radiant, forming a narrow marginal band; central area oval, furnished with numerous transverse moniliform striæ, interrupted by a median blank line. = *C. marginatus*, Johnst. in MJ. viii. p. 13, pl. 1. f. 11; Gr TMS. viii. p. 8, f. 2. Shell-scrapings. New Providence. Californian guano.

C. *eximius* (Greg.).—Disc subcircular, bent; costæ strong, very numerous (often 150), rather short, in a single marginal subradiating circle, enclosing a large hyaline space, furnished with scattered granules and a median line. GDC. p. 31, pl. 3. f. 54. Marine. Loch Fine, Scotland. The costæ of *C. eximius*, like those of *C. Hodgsonii*, are rendered imperfectly radiant by the convergence of those near the end of the median line or raphe. *C. eximius* differs from that species in its less conspicuous and scattered granules, invisible except when highly magnified. Mr. Roper, however, may be right in regarding it as a variety of *C. Hodgsonii*, since Professor Gregory himself states that the granules "in some instances show faint traces of a linear arrangement close to the marginal band."

2* *Disc circular or subcircular, with a double concentric series of costæ.*

C. *centralis* (Greg.).—Disc with about forty, equal radiating costæ, leaving a small umbilical space; the costæ continuous, but divided into two series by a shade-like band, the inner series fainter. GDC. p. 30, pl. 3. f. 51. Marine. Loch Fine, Scotland. Professor Gregory supposes that the appearance of a line which divides the costa is caused by a ridge.

C. *fenestratus* (Grev.).—Disc circular, with marginal radiating costæ divided by a line into two series, the inner one fainter and enclosing a central space occupied by four lattice-like sculptures formed by three or four bars crossing each other at right angles. Grev. in MJ. v. p. 9, pl. 3. f. 4. Marine. West Indies. The continuous costæ are divided, as in *C. centralis*, by a line into two concentric series. A species distinguished by the "four remarkable sculptures, exactly resembling square windows in miniature, the bars sharp and slender, and the panes actually appearing as if they transmitted light," Gr.

C. *Ecclesianus* (Grev.). — Disc subcircular, with a border of two concentric series of very short, radiating costæ, or narrow-oblong cellules; central space with two rows of transverse broad bars, separated by a median line, from each end of which proceeds a semicircle of fine striæ. Gr. *l. c.* p. 10, pl. 3. f. 5. Marine. West Indies. "Similar in size to the last, but somewhat more contorted, so that when one portion of the valve is in focus, the details of the remaining portion are less visible. The valve is concave; the central portion, occupied by the two rows of bars, is nearly flat; but on each side of the rows, and at their termination, the disc is inflated, the lateral inflations being unsculptured, the terminal ones striated," Grev.

C. *bicostatus* (S.).—Disc suborbicular, saddle-shaped, with from twenty to forty unequal radiating costæ, interrupted so as to form two concentric series, enclosing an oblong, smooth central space. Ro. in MT. ii. pl. 6. f. 4; SBD. ii. p. 88. Thames; Norfolk. Diam. about 1-384". Costæ distinct, their length, at sides, about half the radius, at the ends much shorter. Inner series less distinct.

C. *Clypeus* (E.). — Disc suborbicular; rays numerous (40 to 100), radiating, partially interrupted, and forming two incomplete concentric series; the large punctated central space divided by a median smooth line. EM. pl. 10. 1. f. 1; SBD. ii. p. 88. In fresh and brackish waters; also fossil. Asia, Africa, America, Europe, England. Original drawings of this elegant species are given in XVII. 516, 518. Diam. 1-576" to 1-216". Costæ punctated, continuous at the ends, but interrupted at the sides, where they form two series. In the central space are two oblong sculptured portions, separated by the smooth median line.

C. *Remora* (E.). — Disc suborbicular, tortuous, with interrupted rays and a smooth centre. KSA. p. 33. Marine. Baltic. D. 480".

C. *marginatus* (E.).—Disc small, in the middle smooth, subscabrous, furnished in the margin with a double series of cellules, the external fine, the inner larger, evident, closed at the opposite ends, open and radiated in the middle. KSA. p. 33. Maritime. King's Island, India, Ceylon.

C. *fastuosa* (E.).—Disc suborbicular, curved; costæ subdistant, continuous, divided into two concentric series, the outer inflated, inner shorter, stalk-like, enclosing a finely and transversely striated central space. KSA. p. 33. = *C. Thureti*, BDC. pl. 1. f. 41; *C. simulans*, Grev MJ. v. pl. 1, f. 41. Marine. Asia, France, England. *C. fastuosa* is easily distinguished from every preceding species, except *C. marginatus*, by its finely *striate* central space and the peculiar appearance of its costæ, which are divided by a line into two parts, compared by Professor Gregory to a lotus-flower on a stalk. Professors Kützing and Gregory note its resemblance to *Surirella fastuosa*; we believe it, however, quite distinct, as, in addition to its circular and bent form, the central striæ are finer and more numerous. *C. fastuosa* varies considerably in size, and in the comparative breadth of the central portion, which is sometimes a mere line, at others lanceolate, or even oval. The costæ are either interrupted by the prolongation of the central portion to the margin, or continued all round.

C. *ambiguus* (Gr.).—Disc suborbicular; costæ distant, reaching nearly to the centre, partially interrupted at the middle; in the centre an oblong depression, within which is a short, linear-elliptical blank line. Jamaica, Port Natal. Gr MT. viii. p. 31, pl. 1. f. 5. = *C latus*, Sh MT. ii. pl. 1. f. 13.

C. *parvulus* (S.). — Disc subcircular, minute; costæ few (about twelve), in length about two-thirds of radius; central space obscurely striated. SBD. i. p. 30, pl. 6. f. 56. England. (xv. 22, 23.) We have found this form generally accompanying *C. fastuosa*. Like that species, it is sometimes oblong, and probably is only a small variety. It is usually much bent, and is the smallest species known.

3 * *Disc subcircular, with radiating series of granules or perforation-like dots.* Coronia (*Ehr.*).

C. *Echeneïs* (E.).—Disc bent, with numerous irregularly radiating series of conspicuous dots, becoming fewer and more scattered near the centre. KSA. p. 34. = *C. Argus*, BMO. pl. 2. f. 24, 25; *C. cribrosus*, SBD. pl. 7. f. 55. Marine. America, Europe, England. Diam. 1-288″. The costæ are nearly obsolete, and confined to the margin. We refer *C. Argus* to this species upon the authority of our lamented friend the late Professor Bailey.

C. *diplostictus* (Norman).—Disc with conspicuous marginal, moniliform, radiating lines, alternate ones shorter, and a large, subelliptic, central blank space. Grev TMS. viii. p. 31, pl. 1. f. 6. Australia. The cellules of the striæ are linear-oblong, and, being marked longitudinally by a faint line, appear doubled.

C. *heliophilus* (E.).—Disc small, suborbicular, including in the broad and smooth median area a quadrate series of granules, similar series of granules being radiately disposed in the broad margin, and in a double concentric order; the external rays simple, the inner ones binary. KSA. p. 33. Maritime. India, China. The proper arrangement of this and the next species is doubtful.

C. *Indicus* (E.).—Disc large, with a subquadrate, smooth, median area, and a very broad margin formed of fine and dense radiating series of granules in a double concentric order. KSA. p. 33. Maritime. King's Island, India.

Var. *β*. Concentric rays continuous.
Var. *γ*. Concentric rays interrupted.

4 * *Disc subcircular, with a narrow, median, pervious, smooth band, and transverse lateral striæ.*

C.? *striatus* (E.).—Disc with two series of about 13 transverse striæ on each side of the median line. EA. iii. pl. 7. f. 13; KB. pl. 28. f. 11; Bri MJ. vii. p. 79, pl. 9. f. 4. Fossil. Vera Cruz.

5 * *Frustules in lateral view not circular.*

C. *Surirella* (E.).—Disc large, flexuose, oblong; the middle broad and smooth, the margin narrower, with radiating striæ. KSA. p. 33. Aquatic. Spain.

C. *ovatus*.—Disc curved, large, ovate, obtuse, with nine very broad pinnæ in 1-276″. = *Surirella Clypeus*, E. Marine. Baltic. 1-276″.

C. *Ehrenbergii*.—Disc flexuose, small, ovato-elliptic; ends equally rounded; margin striated, with from 10 to 12 costæ in 1-1200″. = *Surirella Campylodiscus*, E. Aquatic. Italy, Mexico. (xv. fs. 12, 13, 22 & 23.)

C. *spiralis* (K., S.).—Spirally twisted, with a dotted margin; laterally elliptic, with about 60 nearly parallel costæ; centre of disc minutely punctate. SBD. i. p. 29, pl. 7, f. 54. Aquatic. Europe, England. (IV. 39.) *C. spiralis* differs from *C. Hibernicus* in its elliptic and twisted, not saddle-shaped frustule. We doubt if it be distinct from *C. flexuosa*.

C. *flexuosa* (E.).—Disc large, flexuose; costæ 4 or 5 in 1-1200″. = *Surirella flexuosa*, E. KB. t. 28. f. 25. Aquatic. Africa, South America, Mexico, France. (XV. f. 11.)

C. *elegans* (E.).—Large, very broad, with subacute ends, and very finely-punctate surface. = *Surirella elegans*, E. KB. t. 28. f. 23. Aquatic. Germany, Mexico. Costæ 4 in 1-1200″. Known only by fragments.

C. *Myodon* (E.).—Small, rather curved, laterally elongated, narrow, with one end rounded (the other unknown), with small, closely-set costæ, giving the margin a toothed appearance. = *Surirella Myodon*, E. KB. t. 28. f. 24. Mexico, Japan, Africa. Costæ 6 or 7 in 1-1200″. Known only from fragments.

C. *Zonalis* (Ph.).—Disc large, greatly deflected; "radii symmetrical to two axes; concentric striation may be detected, and some appearance of punctation on the outer edge." Found in cretaceous, marly deposits. Bridlington, Yorkshire. Prof. J. Phillips, 1845.

Genus CALODISCUS (Rab.).—Discoid; disc subcircular, with numerous (often 64) ray-like bands, each connected at the broad, striated rim with its neighbours, and forming tooth-like straps; centre not striated, clouded, with a lighter transverse one-branched zone. The umbilical zone is probably non-essential, and we doubt whether this genus be distinct from Campylodiscus.

Calodiscus *superbus* (Rab.).—Disc large, flat, with a distinct closely striated rim, and equal radiating costæ enclosing a largish clouded umbilical space. Rab. D. p. 12. t. 3. Aquatic. Italy. (VIII. 56.)

FAMILY VI.—STRIATELLEÆ.

Filaments compressed; the central portion of the frustule furnished with incomplete longitudinal septa, which appear like striæ or costæ. The Striatelleæ form a very distinct group, distinguished from every other by having parallel longitudinal striæ or costæ on the central or connecting portion of the frustule. "The appearance of longitudinal striæ is in fact produced by siliceous plates arising internally from the margins of the filament, and extending towards but not reaching the centre. The interior is thus divided into chambers, opening into a central space. When viewed laterally, this central space resembles a canal, especially as the inner edge of each plate has a concave outline" (Ralfs, ANH. xiii.). The striæ and septa are frequently conterminal; in some genera this appearance is constant, and then the striæ are said to be interrupted. We believe, however, that the striæ are really continuous, although always more strongly marked where they coincide with the septa, and, on the other hand, very indistinct, especially in a young state, when they are merely formed by an internal rib. Prof. Smith adds the following explanation:—"The valves (lateral surfaces) are similar in character to those of the other Diatomaceæ, and are formed during self-division in the same manner; but, instead of the usual repetition of the process of valve-formation, we are here presented with a subsequent intervalvular development which, not confined to the exterior of the frustule, projects a plate of silex into its interior, forming a septum or partition extending towards, but not reaching, the centre of the cell, and appearing as a compressed rim or *annulus* of silex, whose outer or larger circumference follows the exterior outline of the frustule, and whose inner edge bounds the free space which serves as a channel of communication between the chambers into which the cell is thus divided. This process is either simultaneous, and the frustule *definite*, or successive, and the frustule *indefinite*. In the first case the annuli of silex are formed during the production of the valves in the progress of self-division, and on every repetition of such production; while in the second case the formation of the annuli is continued after the production of the valves, and is repeated an uncertain number of times before the recurrence of a new valve-production" (BD. ii. p. 32).

Kützing divides this group into Striatelleæ and Tabellarieæ, but we agree with Meneghini in thinking this division unadvisable. "Any one," says the latter, "examining these beings with diligence, will entirely convince himself that the distinction of the two orders is altogether insufficient. No Tabellaria has a central nodule in the secondary surfaces at all to be compared with that of the Diatomeæ constituting his order Stomaticeæ in his first tribe. I firmly believe that Tabellarieæ and Striatelleæ ought to constitute one family, since the diaphragms, which are considered characteristic of the second exclusively, are not wanting in the first" (M. *l. c.* p. 475).

Genus STRIATELLA (Ag., K.).—Filament of few frustules; stipes long; frustules longitudinally striated, laterally lanceolate, with a median line; septa short, inner ones longest. Marine. The long stipes and absence of transverse striæ on the central portion best distinguish this genus.

STRIATELLA *unipunctata* (Lyngb., Ag.). — Frustules hyaline, subquadrate, with numerous fine, parallel, continuous lines; stipes longer than the frustule. SBD. ii. p. 37, pl. 39. f. 307. Not uncommon in the autumn on Zostera and the smaller Algæ. Filaments minute, pale yellowish-brown, glass-like, and glittering, usually composed of few frustules. The septa are very short. The internal colouring matter is generally collected into a roundish central mass. (IV. 40.)

Genus TESSELLA (Ehr.).—Frustules broadly tabulate, not concatenate, densely striated longitudinally; striæ alternate, interrupted in the middle; stipes none? "It is impossible to judge of the value of the characters that distinguish it from Striatella and Hyalosira whilst we do not know the organic importance or the true structure of the striæ" (M. *l. c.* p. 466).

TESSELLA *interrupta* (E.).—Frustules in front view subquadrate. 1-750″. KB. t. 18. f. 4. Mixed with *Striatella unipunctata*, but less abundant. (VIII. 5.)

Genus HYALOSIRA (K.).—Filaments stipitate; frustules quadrate, septa alternate, interrupted in the middle, and united by very fine lines. "At first I was afraid that I was led by want of skill in observing, to believe that I could see in the two longer species of this genus a continuation of the vittæ from one margin to the other, instead of their being interrupted and alternating as they are figured and described by Kützing. Continuing my observations, I succeeded at last in finding one individual exhibiting to my sight the alternations described; hence I became convinced that the latter condition is not merely inconstant, but even the least frequent. The secondary surfaces are elliptico-acute" (M. *l. c.* 466).

HYALOSIRA *minutissima* (K.). — Shortly stipitate, concatenate; frustules very minute, partially separating in a zigzag manner. 1-5700″. KB. t. 18. f. 3. 2. Mediterranean Sea.

H. *delicatula* (K.).—Shortly stipitate, concatenate; frustules minute, quadrate, partially separating in a zigzag manner. 1-2640″. KB. t. 18. f. 111. 1. France; Adriatic Sea. (IV. 42.)

H. *rectangula* (K.).—Shortly stipitate, subconcatenate, frustules subquadrate, rectangular. 1-1380″. KB. t. 18. f. 3. 3. Adriatic Sea (XIV. 23). Frustules larger than in the preceding species.

H. *obtusangula* (K.).—Longly stipitate, ribbon-like or subconcatenate; frustules quadrate, with obtuse angles. 1-1440″. Adriatic Sea. (XIV. 29.) Frustules larger than in the first two species.

H. *punctata* (Bailey).—Frustules large, united in long chains, rectangular, subquadrate, transversely and uninteruptedly vittate, alternate vittæ granulate in the middle of the frustule, the others furnished with a series of conspicuous puncta. 1853. Tahiti.

H. *Beswickii* (Norman, MSS.).—Septa continued across the filament as curved interrupted costæ; valves oblong, with strongly inflated centre and rounded ends; striæ coarse, 30 in ·001″. New Zealand. On Algæ from Joseph Beswick, Esq. Frustules quadrate; valves sometimes with subcapitate apices. [We are indebted to Mr. Norman for the description of this species.]

Genus RHABDONEMA (K.).—Filaments elongated, shortly stipitate; longitudinal striæ uninterrupted, connected by series of transverse striæ; lateral surfaces having transverse striæ and a median longitudinal line. From the comparatively large size of the frustules in Rhabdonema, greater facility is afforded for examining their structure. The longitudinal striæ or ribs (annuli, Sm.) are continuous, parallel, mostly equidistant, and connected by a series of transverse striæ, so that, in fact, the structure has a latticed appearance.

RHABDONEMA *minutum* (K.).—Septa marginal, alternate; lateral valves oblong or spindle-shaped, inflated at the middle, transversely striated throughout. SBD. ii. p. 35, pl. 38. f. 306. = *Tessella Catena*, Ralfs, *l. c.* xii. (not E.). Europe. 1-1200″. Smaller than *R. arcuatum*, from which it differs in the inflated or gibbous centre of its lateral valves. (IV. 41.)

R. *arcuatum* (Lyngb., K.). — Septa marginal, opposite; lateral valves oblong or linear-elliptic, the transverse striæ absent near their ends. SBD. ii. p. 34, pl. 38. f. 305. = *Striatella arcuata*, Ag., E.; *Tessella Catena*, E. Common. (X. 203, 204.) Differs from *R. minutum* in the form of its lateral valves, and by the absence of striæ near the ends; the series of striæ in the front view are also more conspicuous. Length of frustule 1-570″ to 1-200″.

R. *Adriaticum* (K.).—Frustules with four series of septa (two marginal and two median, the latter shortest at one lateral margin, and gradually longer as they approach the other). SBD. ii. p. 35. pl. 38. f. 305. Common, especially from deep water. On Algæ, which are sold as "Corsican moss." (XIII. 27.) 1-480″ to 1-168″. Easily distinguished by the median series of septa, which, more conspicuous than the marginal ones, are usually more or less curved or oblique, and do not coincide with the ribs, but cross the series of striæ; they also gradually increase in length from one lateral margin to the other, leaving a funnel-shaped median space.

R. *Crozieri* (E.). — Lateral valves turgid; apices obtuse, shortly attenuated; the perforated dissepiments (or spurious joints) striated, varying in number. = *Striatella Crozieri*, ERBA. 1853, p. 529. Assistance Bay. Striæ 18 in 1-1152″. (IV. 43.)

Species known to us only by name.

R. *mirificum* (S.).—"A magnificent species, with filaments occasionally reaching ·0086″ in width, and with alternate and cribrose septa. Septa with several (3 to 12) irregular perforations." SBD. ii. p. 35. Mauritius and Ceylon. Arnott, JMS. vi. p. 92; Brightw. JMS. vii. pl. 9. f. 11. (VIII. 12.)

Genus STYLOBIBLIUM (E.).—Frustules cylindrical, multivalved, not concatenated, valves in a simple straight series, like the leaves of a closed book, with a large median canal, entire (not perforated) at the ends; sculptured; tube smooth. Fossil. Stylobiblium approaches nearest to Biblarium and Tetracyclus; but the frustules in the lateral view are orbicular—a character not met with in the other genera of this family. The species are fossil, and occur only in a fragmentary state.

STYLOBIBLIUM *Clypeus* (E.).—Lateral view with from 15 to 20 short, radiant marginal lines, and 3 or 4 pervious, transverse median ones, frustules in the front view with about 34 laminæ or annuli. EM. pl. 33. 12. f. 28, 29. = *Biblarium Clypeus*, E. Oregon and Siberia. Diameter 1-792″. (IV. 45.)

S. *divisum* (E.).—Disc large, its centre with about 10 transverse parallel lines, not reaching the margin, and separated into two series by a linear longitudinal blank band. EM. pl. 33. 12. f. 30. Oregon. Diameter 1-600″.

S. *eccentricum* (E.).—Disc with 5 to 7 eccentric, pervious, curved lines. EM. pl. 33. 12. f. 31. Oregon. Diameter 1-760″. A fragment of a cylinder contained 9 annuli. The costæ in Ehrenberg's figure resemble those of Tetracyclus, the median one straight, and those above and below curved towards the margin in opposite directions to each other.

Genus BIBLARIUM (E.).—Frustules compressed, lamelliform, with internal septa; lateral view with transverse uninterrupted costæ, but without median inflation. Fossil. All the species are fossil, and, although described by Ehrenberg as simple, were probably filamentous in a recent state. The forms with inflated centre we concur with Professor Smith in removing to Tetracyclus, and indeed only retain the genus because we are unable to ascertain at present the proper situation of the other species noticed here.

BIBLARIUM *compressum* (E.).—Lateral view elliptic-oblong, with obtuse ends and lax, parallel transverse costæ. EM. pl. 33. 12. f. 1. Oregon. 1-648″. Costæ 5 to 7 in 1-1152″. Septa 28 in each frustule.

B. *ellipticum* (E.).—Lateral view elliptic, with broadly rounded ends, and 5 to 8 parallel transverse striæ in 1-1152″. EM. t. 33. 12. f. 2. Siberia and Oregon. 1-1080″. Differs from *B. compressum* only in its more elliptic lateral valves.

B. *Lamina* (E.). — Lateral valves broadly linear, with rounded ends, slightly constricted middle, and 7 to 8 parallel transverse striæ in 1-1152″. EM. pl. 33. 12. f. 4. Oregon. Ehrenberg's figure shows little or no constriction.

B. *lineare* (E.).—Lateral valves narrowly linear, with rounded or subacute ends, and 4 to 8 parallel transverse striæ in 1-1152″. EM. pl. 33. 12. f. 6. Siberia and Oregon. Ehrenberg's figures scarcely differ from those of *B. Lamina*, except in being narrower.

B. *Lancea* (E.).—Lateral valves lanceolate, with subacute apices, and 3 to 8 parallel transverse striæ in 1-1152″. EM. t. 33. 12. f. 5. Oregon. Twenty-seven septa in each frustule. 1-336″.

B. *Castellum* (E.).—Lateral view of central portion elliptic, with obtuse ends, and four marginal undulations. EM. t. 33. 2. f. 1. Siberia. 1-900″. Lateral valves unknown. (IV. 44.)

B.? *gibbum* (E.).—Frustules smooth, bacillar; 2 to 4 together, with straight centre; lateral view gibbous at the middle. KSA. p. 117. Kurdistan. 1-1152″. A doubtful member of this family.

Species known to us only by name.

B. *Chilense* (Eh. Chili.).—"Related to *B. compressum*," EM. p. 301.

B. *constrictum* (E.).—Fossil. North Asia.

Genus GOMPHOGRAMMA (Braun).—Filaments compressed, continuous, of few frustules; septa clavate, alternate, nearly equal; lateral valves elliptic, furnished with straight transverse costæ. Aquatic. Gomphogramma agrees with Tetracyclus in its freshwater habitat and in the strong transverse costæ of its lateral valves, but differs (as we believe, essentially) by its clavate septa, which are not continued as costæ across the central canal. We are not sufficiently acquainted with the structure of Biblarium to decide what may be its relation to that genus; but it is not improbable that further investigation may require their union. Professor Smith thus contrasts Gomphogramma with Tetracyclus:—"In Tetracyclus the valve is cruciform, and the costæ arched; in Gomphogramma the valve is elliptic, and the costæ direct; but these seem rather to belong to specific than generic characters, and the propriety of uniting these genera hardly admits of a question" (ANH. January 1857).

GOMPHOGRAMMA *rupestre* (Braun).—Frustules subquadrate, with from one to three septa on each side and gland-like dots along the junction-margins. Braun in Rab D. pl. 33. t. 9. Freiburg; Pyrenees. This seems to be a mountainous species, and most probably its detection would reward a search in our alpine districts. In its clavate septa it somewhat resembles Terpsinoë, but the resemblance is merely superficial; for the septa in that genus are transverse, and in this longitudinal; consequently they belong to different groups.

Genus TETRACYCLUS (Ralfs).—Filaments free, elongated, inflated at the centre, striated; striæ continued across the inflated centre; septa equal; lateral surfaces costate. Aquatic. The inflated centre and strongly costate lateral surfaces sufficiently characterize this genus. "The genus Biblarium, constituted by Ehrenberg in 1845, appears to differ from the present merely in the solitary character of its frustules; and this character arises from the fossil nature of the gatherings from which Ehrenberg derived his specimens. I feel assured that all the species are filamentous in a living state, and that the greater number of them are casual varieties of *Tetracyclus lacustris*" (SBD. ii. p. 37).

TETRACYCLUS *lacustris* (Ralfs).—Lateral view with the inflations and ends rounded. SBD. ii. p. 38, pl. 39. f. 308. = *Striatella Thienemanni*, EA. p. 136; *Biblarium Stella; B. Glans* and *B. speciosum*, EM. pl. 33; *B. strumosum*, EM. pl. 33. 2. f. 13. Recent, Britain and Iceland; fossil, Oregon and Siberia. (XI. 24, 25.). The median inflation seems variable; it is sometimes so much developed as to form a crucial figure resembling the quaterfoil of a Gothic window, but sometimes merely a slight swelling, as in *Biblarium speciosum* (E.).

T. *emarginatus* (E., S.). — Inflations deeply notched, otherwise like *T. lacustris*, SBD. ii. p. 38. = *Biblarium emarginatum*, EM. pl. 33. 2. f. 6. Recent, Britain; fossil, Siberia and Mexico.

T. *elegans* (E.). — Inflations acute. =

Biblarium elegans, EM. t. 33. 2. f. 4. Fossil. Siberia. Ehrenberg's figure of this species differs from *T. Rhombus* merely in its more developed inflation.

T. *Rhombus* (E.).—Lateral view rhomboid, with subacute angles. = *Biblarium Rhombus*, EM. pl. 33. Fossil. Siberia and Oregon.

T.? *Crux* (E.). — Lateral view cruciform, with transverse parallel striæ and a median suture. = *Biblarium Crux*, EM. pl. 33. 2. f. 3. Siberia. Striæ 18 in 1-1152". A doubtful member of this genus.

Genus TABELLARIA (E.).—Frustules quadrangular, united into a filament, at length partially separating and forming a zigzag chain; septa equal, straight; lateral surfaces inflated at ends and middle. Aquatic. Tabellaria differs from the other genera of this family by having three inflations of the lateral surfaces.

Tabellaria *flocculosa* (Roth, K.).—Joints subquadrate, with from 3 to 7 attenuate septa from each margin; lateral view with three nearly equal inflations; the intermediate portions linear. SBD. ii. p. 45, pl. 43. f. 316. = *Bacillaria tabellaris*, EI. p. 199. = *Navicula trinodis* in part, E. = *Tabellaria vulgaris*, E. Common. (xiii. 29.) Best distinguished from *T. fenestrata* by its less elongated frustules and more numerous septa, which usually alternate with those from the other margin. We believe, however, that each complete septum has an opposite one which is generally rudimentary, though sometimes more developed and conspicuous. 1-860" to 1-480".

T. *ventricosa* (K.). — Frustules as in *T. flocculosa*, but the central inflation of the lateral view much larger than the terminal ones. KB. t. 30. f. 74. = *T. biceps*, EM. several figures. (xiii. 26.) Common. 1-960". Professor Smith unites this to *T. flocculosa*, and, as we believe, justly, since intermediate forms are not uncommon.

T. *Gastrum* (E.).—Very small; lateral view with a subglobose median inflation and somewhat narrower capitate apices. KSA. p. 119. Fossil. Labrador.

T. *robusta* (E.). — Thick, three times as long as broad, with broad gibbous centre and large subacute terminal capitula. EM. pl. 33. f. 15. Fossil. America. 1-864". Probably another variety of *T. flocculosa*.

T. *amphilepta*, EM. pl. 3. 4. f. 32. Fossil. Boston. Ehrenberg's figure shows the lateral view with inflated centre, as in *T. flocculosa*; but the extremities are not dilated.

T. *nodosa* (E.). — Small, slender, nodose; nodules five, the median one rather largest, those adjoining oblong. EM. several figures. Siberia. Lough Mourne deposit, &c. Ehrenberg's figures are elongated, with four constrictions, and consequently five inflations, of which the median and terminal are suborbicular and the intermediate oblong. "Akin to *Grammatophora undulata*" (E.).

T. *fenestrata* (Lyng., K.).—Front view linear, with two opposite septa from each end; lateral view with three nearly equal inflations and linear connecting portions. KB. t. 17. f. 22. = *Tabellaria trinodis*, EM. many figures. Common. 1-600" to 1-280".

Species doubtful, or known to us only by name.

T. *amphicephala* (E.). — Very small, with strongly inflated centre and capitate apices. KSA. p. 119. Fossil. San Fiore. 1-1728". Scarcely distinct from *T. ventricosa*.

T. *platystoma* (E.), Sandwich Islands; *T. rhabdosoma* (E.), Asia; *T. pinnularia* (E.), Asia; *T. clavata* (E.), Northern Asia; *T. undulata* (E.), Northern Asia; *T. eurocephala* (E.), Persia; *T. Semen* (E.), India; *T. Bacillum* (E.).

Genus GRAMMATOPHORA (E.).—Frustules forming a filament, at length partially separating and becoming a zigzag chain; septa in pairs, opposite, generally curved; lateral view oblong-lanceolate, not inflated. Grammatophora is easily distinguished from all the other genera by its striæ having commonly a curve outwards near the base; and when this curve is wanting it may be known from Tabellaria by the absence of inflation. Although Kützing describes several species of this genus as smooth, yet we believe that all the species are striated; and notwithstanding we have admitted this character into some of the definitions, we use it merely to indicate that the striæ are more distinct and more easily detected.

* *Lateral view oblong or lanceolate, sometimes slightly constricted beneath the apices.*

† Septa straight or funnel-shaped.

GRAMMATOPHORA *stricta* (E.). — Large, with straight, parallel septa; lateral view lanceolate. KB. t. 29. f. 76. Asia, Africa, America.

G. *parallela*, EM. pl. 21. f. 26. We know not how this form differs from *G. stricta*, except that the figures of the lateral valves exhibit more rounded apices.

G. *Tabellaria*, EM. pl. 18. f. 89, 90. Fossil. Virginia. In Ehrenberg's figures the front view has the septa slightly curved and dilated inwards (funnel-shaped); lateral view lanceolate, with a large central canal.

2 † Septa with a semicircular curve near the marginal ends; otherwise straight.

G. *marina* (Lyng., K.). — Septa with a single curvature; lateral view linear-oblong, gradually tapering into the obtuse apices. KB. t. 17. f. 24. = *Diatoma tæniæforme*, *D. marinum* (Lyng.), and *D. latruncularium* (Ag.), *D. brachygonium* (Carm.), *Bacillaria Cleopatræ* (E.), *B. Adriatica* and *B. Meneghina* (Lobarzewsky), *Grammatophora oceanica*. Everywhere. Common, often forming long chains. (IV. 47; XI. 52, 53.) The synonyms are adopted from Kützing, and probably some of them belong to other species. The frustules are of very variable length, sometimes nearly square, sometimes many times longer than broad. Connecting hinge slender.

G. *tropica* (K.).—Large, with striated margin; septa with a single curvature; lateral view linear, with rounded apices. KB. t. 30. f. 71. Cape of Good Hope. 1-600″ to 1-156″. Connecting hinge tumid.

G. *gibba* (E.).—Large, striated; septa curved at outer end, otherwise straight; lateral view linear, with slightly inflated centre and rounded ends. KB. t. 29. f. 77. Cuba. (XI. 48, 49.)

G. *Mexicana* (E.).—Large; septa with a single curvature; lateral view constricted beneath the rounded apices. KB. t. 18. f. 1-6. Europe, America. Connecting hinge tumid.

G. *gibberula* (K.). — Margin striated; septa once curved; lateral view lanceolate, with tumid centre and obtuse apices. KB. t. 30. f. 81. Naples. 1-450″. Connecting hinge slender. Differs from *G. Mexicana* in its distinctly striated margin and more lanceolate lateral view.

G. *macilenta* (S.). — Frustules often curved; septa as in *G. marina*; lateral valve linear, slightly inflated at centre and extremities; striæ 60 in ·001″. SBD. ii. p. 43, pl. 61. f. 382. Britain; Levant. "The front view in this species is always narrower in proportion to its length than in *G. marina*. The striæ are also far more numerous; and the frustule, especially in the larger specimens, shows a decided tendency to assume a curved form."

3 † Septa lunately curved, both ends hooked inwards.

G. *hamulifera* (K.). — Small, subquadrate; septa curved throughout, with their concavities towards each other. KB. t. 17. f. 23. Common, especially from deep water. (XIII. 22.) 1-2400″ to 1-960″. Distinguished by its small quadrate frustules and uniformly curved septa. It is possible, however, that it may be the immature state of one of the following species.

4 † Septa undulate, inner ends incurved.

G. *angulosa* (E.). — Septa hooked inwards, at inner end and near the margin of frustule with angular curve inwards. KB. t. 30. f. 79. Atlantic and Pacific Oceans. Perhaps a variety of *G. Africana*.

G. *Africana* (E.). — Septa with three undulations, the inner ends incurved; lateral view lanceolate, obtuse. EM. pl. 19. f. 34. Fossil, Oran; recent, not uncommon. 1-2300″ to 1-480″.

G. *Islandica* (E.). — Septa with three undulations, curved at the centre; lateral view navicular, striated. KSA. p. 121. Iceland.

G. *serpentina* (E.).—Large, with striated margin; septa with several undulations and incurved inner ends; lateral valves linear, with attenuated ends and obtuse apices; connecting hinge thick. SBD. ii. p. 43, pl. 42. f. 315. = *G. Mediterranea* (E.), according to Kützing. Not uncommon in sheltered bays. Remarkable for its serpentine septa, the number of curves seeming to vary according to the length of the frustule; and we fear that some of the allied species are not really distinct from it. Professor Smith informs us that, in this species, Mr. West finds the dots disposed in quincunx, and the lines consequently oblique. (IV. 48.)

G. *anguina* (K.). — Large, smooth; septa serpentine, with the interior end hooked inwards. KB. t. 17. f. 25. Atlantic and Antarctic Oceans. 1-650″ to 1-360″. We see not how this differs from *G. serpentina*, as we believe that no species in this genus is really smooth.

2* *Lateral view with four constrictions.*

G. *undulata* (E.).—Lateral view linear, with four constrictions and rounded ends; septa in front view undulated. KB. t. 29. f. 68. Fossil, Greece; recent, America. 1-860″.

3* *Lateral view lunate.*

G. *arcuata*, EM. pl. 35 A. 23. f. 11, 12. Assistance Bay. The figures represent the front view with undulated septa, and the lateral one lunate, with transverse lines and a central canal.

G. *curvata*, EM. pl. 35 A. 22. f. 13. Antarctic Ocean. The figure shows the lateral view, like that of *G. arcuata*; but its central canal is smaller, and there are no transverse lines.

G. *subtilissima*. — Striæ fine. A good test for high powers.

Genus GEPHYRIA (Arnott).—Frustules attached; front view with sublamellate, finely striated connecting zone, destitute of septa; valves arcuate, dissimilar, with transverse costæ interrupted by a longitudinal line. Marine. We place Gephyria with the Striatelleæ because of its resemblance to Eupleuria; but the absence of septa renders its proper position somewhat doubtful. The lower valve differs from the upper one in having a smooth circular space at each end. The strongly arched valves and absence of septa distinguish it from Eupleuria. It differs from Achnanthes by having no central nodule.

GEPHYRIA *incurvata* (Ar.).—Costæ of valve about 7 in ·001″; connecting zone with stout longitudinal costæ. Ar MJ. viii. p. 20. = *Eupleuria incurvata*, Ar MJ. vi. p. 90; *Achnanthes costata*, Johnstone, MJ. viii. p. 20, pl. 1. f. 14. South African and Patagonian guano.

G. *media* (Ar.).—Valves obtuse, with 11 costæ in ·001″. Ar MJ. viii. p. 20. *Achnanthes angustata*, Johnstone, MJ. viii. p. 20, pl. 1. f. 13. Californian guano.

G. *Telfairiæ* (Ar.). — Valves with acute cuneate ends, and 15 costæ in ·001″. Ar MJ. viii. p. 20. Mauritius.

Genus EUPLEURIA (Arnott). — Frustules united into short, attached filaments; front view annulate, indefinite, with short septa and beaded margins; valves dissimilar, costate; costæ interrupted by a longitudinal line, those of lower valve fewer and central. Marine. Eupleuria differs from Rhabdonema by its dissimilar valves, the transverse costæ of the lower one being confined to the middle—a character conspicuous even in the front view, since the ends of the costæ are there seen as marginal bead-like dots. The valves have some resemblance to those of Achnanthes, but have no central nodule or stauros.

EUPLEURIA *pulchella* (Ar.). — Front view with stout longitudinal costæ connected by transverse bars, very short septa; and punctated lateral margins. Ar TMS. vi. p. 89. New Zealand and Australia. The frustules, in the front view, have the cellulate structure of Rhabdonema; but the septa are so abbreviated as to seem mere marginal dots, and the puncta on the ventral margin are confined to the middle. Annuli close, numerous; valves usually turgid at the middle and rapidly tapering to the obtuse apices (subovate), but sometimes linear-oblong. In the lower valve the costæ and longitudinal line are present only at the middle portion, and leave a large hyaline blank space at each end. Striæ between the costæ, and oblique.

E. *ocellata* (Ar.). — Front view with longitudinal lines, fine transverse striæ, and costate lateral margins; costæ of ventral margin longer, confined to the middle, and divergent. Ar TMS. vi. p. 9. New Zealand. In *E. ocellata* the frustules are more hyaline than in *E. pulchella*, and the longitudinal costæ less conspicuous, and not connected by transverse bars. The most evident distinction, however, is the clavate or capitate lines of the dorsal and ventral margins, those of the latter being longer, fewer, and divergent. The septa seem to be rudimentary, as in the preceding species. Valves oblong-linear, sometimes curved, with rounded ends.

Genus ENTOPYLA (Ehr.).—Frustules prismatic, compressed, multivalved; valves contiguous, in a straight, simple series, like the leaves of a book; internal ones traversed by a large median opening; outer ones transversely striated, unequal, one entire (not perforated), the other furnished with a large pore at each end. Marine. Entopyla, by its curved form, approaches Achnanthes; by its tabulate figure it is more akin to Tessella; but it comes nearer to Biblarium than to any other. Although, in deference to the opinion of Professor Arnott, we have kept Eupleuria distinct from this genus, we doubt the propriety of doing so. From Ehrenberg's comparison of Entopyla with Tessella and Biblarium, and bearing in mind his peculiar views, it is evident that the "internal valves" are the "annuli" of Smith, and the "perforations of the ventral valve" the blank spaces at each end. Since the opening in the internal valves is stated to be so large as to leave only a thin margin, the septa must be rudimentary. Both Entopyla and Eupleuria seem therefore to differ from Rhabdonema in their dissimilar valves and rudimentary septa, nor are we able to find any character in Ehrenberg's description which enables us to distinguish Entopyla from Eupleuria.

ENTOPYLA *Australis* (Ehr.).—Leaves (annuli) about 16; transverse costæ of outer ones (or valves) 32 to more than 40 in number, divided by a median flexuose line. ERBA, 1848, p. 42. = *Surirella Australis*, Ehr. 1843. Patagonian guano.

Genus DIATOMELLA (Grev.).—Frustules quadrangular, forming at first a plano-compressed filament, at length separating; vittæ two, interrupted in the middle and at each end.=Disiphonia, E. Aquatic. Professor Smith doubtfully referred to Grammatophora the Diatom for which this genus was constituted; but we consider the differences pointed out by Dr. Greville as sufficient, independently of its aquatic habitat, to separate it from that genus. In Grammatophora the septa are formed in the central or connecting portion, arise from the margins of the filament, and are interrupted in the middle. In Diatomella they appear to us to arise from a thickened rib connecting the lateral and central portions, and form imperfect diaphragms with three openings—one central, the others marginal. We have included Diatomella in this family, but, although Professor Smith states that its frustules are annulate and nearest in structure to Grammatophora, we are not sure it is rightly placed here; for two puncta exist at each end of the frustule, as in the Fragilarieæ.

DIATOMELLA *Balfouriana* (Gr.).—Lateral view linear or oblong, with rounded ends and 45 fine striæ in ·001." GANH. s. 2. xv. pl. 9. fs. 10–13. = *Grammatophora? Balfouriana*, SBD. ii. p. 43, pl. 61. f. 383. = *Disiphonia Australis*, EM. pl. 35A. f. 7. South Africa, South America, Scotland. Front view quadrangular, with a smooth central portion, separated from the transversely-striated lateral valves by the vittæ. (IV. 51, 52.)

FAMILY VII.—MELOSIREÆ.

Frustules disciform, cylindrical, or globose, simple or united into a filament; lateral surfaces flat or convex, circular, smooth or with radiating striæ, less frequently cellulose, granulate or punctate; front view with the central portion usually either obsolete or divided by one or two central furrows. "For the most part the Coscinodisceæ are related to this family, with which they have been hitherto united by Ehrenberg; but I have separated them because the shell of the Coscinodisceæ often has divergently arranged bands and a cellulose formation, which is wanting in the Melosireæ. Moreover the forms of the genus Melosira have in life so great similarity to the true simple Confervæ, that they may easily be confounded even by practical Algologists. The heating of a specimen upon mica, however, distinguishes them so certainly that we can never be in doubt" (Kützing). The line of demarkation between the Melosireæ and Coscinodisceæ is by no means well established; generally, discoid forms with cellulose structure belong to the latter, and filamentous or smooth species to the former. This family, however, contains some distinctly cellulose species; but they are distinguished by their inflated or vaulted segments and the absence of a central portion.

We have removed some genera Kützing had placed here, as we consider Mr. Brightwell has proved that they are more akin to Chætoceros.

Genus CYCLOTELLA (Kütz.).—Frustules disciform, simple or binately conjoined; central portion ring-like; valves plane or slightly convex. Aquatic and marine. = Discoplea, Ehr. Cyclotella differs from Melosira in not forming a filament. The recent species, according to Kützing, are either adnate or enclosed in a shapeless gelatinous substance. Some of the species approach closely in character to Coscinodiscus. We retain Kützing's name because it has the claim of priority.

CYCLOTELLA *operculata* (K.).—Valves depressed in the centre; striæ obscure, very short; front view with rounded angles. SBD. i. p. 28, pl. 5. f. 48. Fresh water. Europe. This species is involved in great confusion, and we confess our inability to reduce it. We have adopted Professor Smith's views, though with much hesitation. Kützing describes the margin as punctated; and his figures, though varying much in size, of the umbilical portion, show the margin closely and irregularly punctate, whilst Smith describes them as striated. Kützing refers here the *Discoplea Kützingii* (E.); but that form, according to the figures in the 'Microgeologie,' is larger, with radiating striæ reaching to the centre of the disc. (v. 53.)

C. *rectangula* (Bréb.).—Similar to *C. operculata*; but the frustules in the front view have acute angles. Rab D. p. 11. France. By Kützing made a variety of *C. operculata*, by Smith of *C. Kützingiana*. (v. 54.)

C. *Scotica* (K.). — Frustules adnate; disc plane, very smooth. KB. t. i. f. 2, 3. = *C. Ligustica*, K. *l. c.* t. 1. f. 4. On marine algæ. Scotland, &c. We unite *C. Ligustica* to this species, since Kützing makes no distinction except size, which in the Diatomaceæ is too variable to be made the only specific difference. D. 1-960" to 1-516". (XIV. 17.)

C. *maxima* (K.).—Frustules large, adnate; disc nearly plane, punctated. K. *l. c.* t. 1. f. 5. On Algæ in the Pacific. Diam. 1-300" to 1-126". Puncta scattered.

C. *Coscinodiscus* (E., K.).—Disc small, irregularly but densely and finely granulate, margin smooth. = *Discoplea Coscinodiscus*, EM. pl. 33. 10. f. 1, 2. Fossil. United States. Habit of *Coscinodiscus minor*, rather turgid on the sides. D. 1-1728".

C. *Mammilla* (E., K.).—Disc smooth, umbonate in the centre; suture in front view tumid, produced at the margins. = *Discoplea Mammilla*, EM. pl. 38. 22. f. 1–3. Fossil. Patagonia. The suture between the valves is ridge-like, and consequently projects at the margins. Rim of disc striate. Diam. 1-1728".

C. *umbilicata* (E.).—Disc smooth, with a central smooth umbo. = *Discoplea umbilicata*, EM. pl. 35 B. B. f. 9. From Atlantic deep soundings. Ehrenberg describes this species as smooth, but figures it with a punctated centre.

C. *Americana* (E., K.).—Frustules in front view turgid, with a transverse, tricarinated ring; disc punctate in the centre. KSA. p. 19. United States. Diam. 1-660".

C. *physoplea* (E., K.).—Disc smooth, except a circlet of large vesicular-looking granules round the centre. = *Discoplea physoplea*, EM. pl. 33. 17. f. 8. Fossil. Virginia. Diam. 1-1152".

C. *comta* (E., K.).—Disc with a circlet of small striæ near the margin, and a crowded central mass of granules. = *Dis-*

coplea comta, EM. pl. 38. 1 B. Asia, Africa, &c. Front view tumid at the sides. Although this species is said to have a granulated umbilicus, none of Ehrenberg's figures exhibit this character.

C. *dendrochæra* (E.). — Disc smooth, except a circlet of short rays. = *Discoplea dendrochæra*, E. On trunks of trees. Venezuela. Frustules small, tumid in front view. Diam. of disc 1-1920″; central circlet with about ten rays. Habit of *C. comta*.

C. *atmospherica* (E.). — Disc with a central, rather turgid umbilicus, from which radiate numerous striæ. = *Discoplea atmospherica*, EM. pl. 39. 1. f. 17. In atmospheric dust. Diam. 1-1008″.

C. *Sinensis* (E.).—Disc with a central, rather turgid, granular umbilicus, from which radiate numerous striæ; the striæ separated from the umbilicus by a border. = *Discoplea Sinensis*, EM. pl. 39. 1. f. 16. Atmospheric dust. China, &c. Diam. 1-864″. Rays much closer than in *C. atmospherica*, and smooth, not rough as in that species. In front view linear, with striated margins. (xv. 4.)

C. *Atlantica* (E.).—Disc with a central, somewhat granular umbilicus, from which proceed numerous radiating lines. = *Discoplea Atlantica*, EM. pl. 39. 3. f. 29. Atmospheric dust. Atlantic. Smaller than the last, and its umbilicus not circumscribed by a rim; but we doubt whether this and the two preceding species are sufficiently distinct. (xv. 3.)

C. *Oregonica* (E.). = *Discoplea Oregonica*, EM. pl. 37. 2. f. 3. Oregon. Ehrenberg's figure represents a small disc with a central punctated umbilicus, from which proceed numerous rays. Front view linear, with marginal striæ. Does this differ from *C. Sinensis*?

C. *venusta* (E.).—Disc with granulated umbilicus and numerous smooth rays. = *Discoplea venusta*, ERBA. 1852, p. 534. Alive. California. Akin to *C. atmospherica*; frustules with the stellate habit of Actinocyclus. Ehrenberg observed three specimens. In one the umbilicus was nearly equal to a fourth part of the diameter of the disc, and the entire surface very nearly smooth; in another the surface was distinctly granulated, and the umbilicus, having its margin obliterated, was scarcely evident.

C. *Astræa* (E., K.).—Disc with a large punctated centre and densely-rayed margin. KSA. p. 19. = *C. Rotula*, KB. t. 2. f. 4; SBD. pl. 5. f. 50? Kurdistan; Ireland. Diam. 1-636″. It has the habit and size of *Melosira varians*, but is not concatenate. *C. Rotula* is a marine species.

C. *Peruana* (E., K.).—Disc with very fine rays, reaching to the centre. = *Discoplea peruana*, EM. pl. 38 A. 14. f. 6. In pumice from Arequipa and Santiago, Peru. Resembles *C. Astræa*. Diam. 1-600″. The thickness of the frustule equals half its length. Although the rays are described as reaching the centre, the figures show an umbilical space.

C. *oligactis* (E.). = *Discoplea*? *oligactis*, EM. pl. 35 A. 9. f. 1. Ganges. Ehrenberg's figure shows a small disc, with striated rim and irregular umbilical space, from which proceed a few irregular rays.

C. *Græca* (E.).—Disc plane, interruptedly striated in a radiate manner. = *Discoplea Græca*, E. = *Coscinodiscus Græcus*, KSA. p. 125; EM. pl. 6. 2. f. 1. Fossil in Greece. Diam. 1-864″.

C. *antiqua* (S.).—Valves convex; striæ broad, not reaching the margin. Diam. ·0009″ to ·0013″. SBD. i. p. 28, pl. 5. f. 42. Lough Mourne and Peterhead deposits, &c.

C. *picta* (E., K.).—Disc plane, broadly granulated in the middle, its margin densely radiated; rays very slender, elegantly mixed with pairs of stouter ones. KSA. p. 20. African coast. Disc sometimes large.

C. *Rota* (E., K.). — Disc large, with numerous (52) equal rays, not reaching to the centre; surface papillose; papillæ unequal, smallest between the rays, largest at the centre. = *Discoplea Rota*, EM. pl. 35 A. 22. f. 6. Southern Ocean. Diam. 1-192″. This and the next species are distinguished from the rest by having papillæ or granules in the intervals of the rays.

C. *Rotula* (E., K.). — Resembles *C. Rota*, but is smaller, its rays fewer in number (20), and its papillæ equal. = *Discoplea Rotula*, EM. pl. 35 A. 22. f. 7. Southern Ocean. Diam. 1-696″. As in *C. Rota*, the rays extend from the margin towards, but do not reach the centre.

C. *denticulata* (E., K.).—Disc marked with straight, parallel, granulated lines, and its margin denticulate. KSA. p. 20. Bermuda. Diam. 1-672″. In the character of its margin it resembles *Melosira sulcata*, but in the arrangement of its granules it approaches *Coscinodiscus lineatus*.

C. *undulata* (E., K.).—Disc with radiating lines of very minute granules, and an undulated margin. = *Discoplea undulata*, EM. pl. 33. 18. f. 3. Bermuda. Diam. 1-576″. Marginal flexures about fifteen.

C. *stylorum* (Br.).—Valve with styliform rays diverging from the centre, and ending near the margin with a large circular head; centre irregularly punctate. Sierra Leone. Br TMS. viii. p. 96, pl. 6. f. 16.

C. ? *radiata* (Br.).—Valve with simple, strongly marked radii, reaching nearly to the centre; centre smooth; in front view the ends of the radii appear as puncta. West Indies, Monterey. Br. *l. c.* p. 96, pl. 6. f. 11. As many as ten frustules have been found in union; this may, therefore, belong to Melosira.

C. *punctata* (S.).—Frustules with undulations; valves delicately punctate or cellulate; cellules radiate. Diam. ·0008″ to ·0015″. Fresh water. England. SBD. ii. p. 87. (VIII. 13.)

C. *Dallasiana* (S.).—Valves with marginal costæ; centre cellulate; cellules irregular. Length of costæ ·0002″; Diam. of valve ·022″. Brackish water. England. SBD. ii. p. 87.

Genus ACTINOGONIUM (Ehr.).—Frustules suborbicular, many-angled; disc smooth, with radiating lines. Actinogonium, like Liostephania, differs from the rest in being smooth.

ACTINOGONIUM *septenarium*, EM. pl. 36. f. 39. Barbadoes. Rays (7) dividing the disc into compartments, separated from the margin by a regularly-undulated border. Between the centre and border is a circlet of very short lines, two in each compartment. (V. 55.)

Genus LIOSTEPHANIA (Ehr.).—Frustules simple, orbicular; disc smooth, but with a crown of rays encircling a large smooth central space or umbilicus. Liostephania is distinguished by its disc being smooth, and having a circlet of striæ, which striæ do not reach the margin.

LIOSTEPHANIA *Rotula* (E.). — Disc having from six to fourteen simple rays. EM. pl. 36. f. 40. Barbadoes. (V. 57.)

L. *comta* (E.).—Disc with from six to thirteen rays, connected exteriorly by a circlet of puncta. EM. pl. 36. f. 41. Barbadoes. This species differs from the preceding one in the presence of puncta.

L. *magnifica* (E.).—Disc with its rays alternating inwards with pairs of very short striæ, and connected exteriorly by a circlet of puncta. EM. pl. 36. f. 42. Barbadoes. (V. 56.)

Genus DICTYOLAMPRA (Ehr.).—Frustules orbicular, not concatenate; disc without an umbilicus, but having a circular cellular centre, with radiating striæ, which alternate with other striæ from the margin.

Dictyolampra differs from the other genera of this family by its disc being cellulose only in the centre, and indeed it probably ought, together with Liostephania and Actinogonium, to form a distinct family; but, having seen no specimens, we are unable to decide on their proper position.

DICTYOLAMPRA *Stella* (EM. pl. 36. f. 38). Barbadoes. The only species. In the centre is a large, circular, loosely cellulose umbilicus, with numerous (about 20) short radiating lines, which alternate with similar ones directed inwards from the margin; between the latter are interposed very short marginal striæ. (V. 58.)

Genus MASTOGONIA (Ehr.).—Frustules simple (unequally), bivalved; valves not cellulose, in lateral view circular, unarmed, with lines radiating from a stellate or angular umbilicus. These forms, which were formerly placed in Pyxidicula, may be recognized by their unequal and angular valves, radiating veins, and noncellular surface. The definitions of the species in this genus are unsatisfactory, depending almost entirely on the number of rays—a character which we regard as very variable.

MASTOGONIA *Crux* (E.). — Valves large, one with four, the other with seven radiating lines; apex not truncated. EM. pl. 33. 18. f. 8. Bermuda. Diam. 1-396″. Umbilicus stellate.

M. *quinaria* (E.).—Valves large, one

with five radiating lines, the other unknown; apex not truncate. KSA. p. 25. Bermuda. Diam. 1-480″. Scarcely more than a variety of the preceding species.

M. *Rota* (E.).—Valves large, one with six, the other with seven radiating lines; apices entire. KSA. p. 25. Bermuda. Diam. 1-360″. Probably another variety of *M. Crux*.

M. *sexangula* (E.).—Valves thin, one with six radiating lines, the other unknown; apex broadly truncate, with a hexagonal area. EM. pl. 33. 17. f. 12. Virginia. Diam. 1-1632″. Resembles a truncated six-sided cone. All the above species are very smooth and crystalline.

M. *heptagona* (E.).—One valve with seven, the other with nine rays; apex truncated. Bai AJS. xlviii. pl. 4. f. 12. Bermuda. Diam. 1-840″.

M. *Oculus-Chamæleontis* (E.).—One valve having eight radiating lines and truncate apex, the other unknown. KSA. p. 25. = *Pyxidicula Oculus-Chamæleontis*. Maryland. Diam. 1-1152″.

M. *Actinoptychus* (E.).—One valve with 9, the other with 13 flexuose radiating lines; apices broadly truncate. = *Pyxidicula? Actinoptychus*, EM. pl. 18. f. 19. Virginia. This species seems distinct in its flexuose rays and the undulated margin of its umbilicus. (v. 59.)

M. *Discoplea* (E.). — Valves small, conic, with 18 to 20 rays; apices smooth, truncate. KSA. p. 25. In Patagonian pumice. Diam. 1-1152″.

Genus STEPHANOGONIA (Ehr.).—Valves as in Mastogonia, but their truncated apices have spinous angles.

Distinguished by the rays being prolonged into spines, and forming a fringe round the umbilicus.

STEPHANOGONIA *quadrangula* (E.).—Valves thin, smooth, with truncated apices, one having four, the other six ray-like angles and spines. KSA. p. 26. Bermuda.

S. *polygona* (E.).—Valve with central portion smooth and much elevated, united to the margin by an indefinite number of rays, the spaces between which are sometimes faintly punctate; the umbilicus sometimes surrounded with spines. Virginia and Bermuda deposits. EM. pl. 33. 18. f. 10; Br JMS. viii. p. 97, pl. 5. f. 8. (v. 57.)

Genus CLADOGRAMMA (Ehr.).—The characters of this genus are unknown to us.

CLADOGRAMMA *Californicum* (E.). — Valve orbicular, not cellulose, marked with flexuose lines radiating from the centre, and irregularly forked or divided near the margin. California. EM. pl. 33. 13. f. 1**. (VIII. 11.)

Genus HYALODISCUS (Ehr.).—Frustules simple, disciform; disc smooth, flat, its umbilical portion or centre separated by a distinct suture.

Kützing unites this genus with Cyclotella; but its comparatively large hyaline disc, with a centre distinguished by an evident suture, and usually somewhat coloured, is perhaps sufficient to justify its removal. Its flat disc will distinguish it from Podosira.

HYALODISCUS *Patagonicus* (E.).—Disc large, very smooth, its margin separated from the large centre by a slightly grooved but not denticulate suture; junction-line in front view very tumid. EM. pl. 38. 22. f. 10, 11. In pumice from Patagonia. Diam. 1-432″.

H. *lævis* (E.).—Disc large, smooth, its central portion separated by a fracture-like suture. EM. pl. 33. 15. f. 17. *Cyclotella lævis*, Kütz. Virginia. Diam. 1-456″. Allied to *Cyclotella physoplea*. The suture between the valves is not tumid, and the central portion of the disc is smaller, and hence more distant from the rim, than in *H. Patagonicus*.

H. *stelliger* (Bai.).—Disc with a broad margin covered with distinct rectilinear rows of dots, arranged in groups so as to produce a stellate appearance. BC. vii. Abundant. St. Augustine, Florida. "The markings in this species are quite distinct; and the stellate appearance, resembling that shown by *Coscinodiscus subtilis*, will at once distinguish it from all other species," B.

H. *subtilis* (Bai.).—"Disc marked like the engine-turned back of a watch, with lines of exceeding delicacy, only visible by the highest magnifiers and careful illumination; umbilical portion more coarsely granulated and in size little less than one-third of the diameter of the disc," B. *l. c.* pl. 1. f. 12. Halifax, Nova Scotia. "*H. lævis* differs by having a wider margin and much coarser markings. This species forms an admirable test-object," B. (v. 60.)

Genus LYSICYCLIA (Ehr.).—The characters of this genus are unknown to us. From Ehrenberg's figures it appears closely related to Hyalodiscus, the disc having a central, circular umbilicus, and a broad border separable at the suture, as in that genus.

LYSICYCLIA *Vogelii*, ERBA. 1856, p. 333, f. 29. Central Africa. (VIII. 39.)

Genus PODODISCUS (Kütz.).—Frustules as in Podosira, but affixed by a lateral stipes. Marine. We think that the lateral position of its stipes is scarcely sufficient to separate Pododiscus from Podosira.

PODODISCUS *Jamaicensis* (Kütz.).—Frustules simple, concatenate, smooth; stipes elongated, delicate. KSA. p. 26, pl. 16. f. 28. On *Enteromorpha ramulosa*, Jamaica. Diam. 1-840″. (XIII. 28.)

Genus PODOSIRA (Ehr.).—Frustules united into short filaments, having a distinct central stipes; interstitial portion obsolete; valve convex. Marine.

In Podosira the lateral valves are vaulted, and the central portion is at first a mere connecting ridge between them. This ridge, however, becomes gradually broader, and then double; afterwards an intermediate growth separates the halves of the frustule, which meanwhile do not increase in size; and at last, when the intermediate space equals the diameter of the original frustule, two new frustules are formed by the addition of a hemisphere on the inside of each of the separated portions. The outer silicious covering still remaining, the frustules are connected in pairs, and appear like two globules within a joint. The valves usually have a central, coloured umbilicus—an appearance which Professor Smith attributes, in our opinion erroneously, to an absence of silex at that point.

PODOSIRA *Montagnei* (Kütz.).—Frustules subspherical, dotted; connecting sheath with parallel annular series of minute striæ. SBD. ii. pl. 49. f. 326. =*P. Adriatica*, Mo. on Diat.; *Melosira globifera*, Ra ANH. xii. Britain, France, &c. (v. 61.)

P. *Hormoides* (Kütz.).—Frustules oval, united into short moniliform filaments; connecting sheath obscurely punctate; lateral view with umbilicus but no rays. SBD. pl. 49. f. 327.=*P. nummuloides*, E. (II. 45.) Atlantic, Britain, &c. Distinguished from the preceding species by its more depressed valves.

P. *maculata* (S.).—Disc with a large central umbilicus, which is bordered by an irregular, fracture-like suture, from which radiate outwards several shadow-like bands; surface punctated. SBD. ii. p. 54, pl. 49. f. 328. Common in deep water, guano, &c. Britain. It may be identical with *Craspedodiscus Stella*, E.

P. *compressa*, West. (VIII. 34.)

P. *lævis* (Greg.).—Frustules transparent, glassy, with very delicate oblique striæ and scattered puncta; connecting zone distinctly striated; disc without a distinct umbilicus. Grev MJ. vii. p. 85, pl. 6. f. 15–17. Scotland.

Genus MELOSIRA (Ag.).—Frustules cylindrical, discoid, or globose, connected into cylindrical conferva-like filaments, one or two lines passing round each frustule near the centre.=Gallionella, Ehr. Maritime and aquatic. This genus is easily distinguished from the other genera of the Diatomaceæ except Pododiscus, with which the species in its first section closely correspond in character. The filaments are remarkable for their conferva-like appearance, but may be known by their brown colour and very fragile nature. The species are numerous, and sometimes differ very slightly; we fear indeed that several of them have been constituted upon insufficient grounds. Attempts, more or less successful, have been made to remove some species, and to form with them new genera. We have used these divisions as sections, partly because we are unable to find at present differential characters sufficient to justify a more complete separation, and partly because we cannot decide absolutely on the proper position of several species. The following are the sections we have adopted:—

* *Lysigonium.*—Joints globose or elliptic, with a ring-like keel round each valve. In this section the frustules resemble in form those of the two preceding genera, but are distinguished by their carinated valves. The suture is a ridge between the valves.

2 * *Gallionella.*—Joints cylindrical or suborbicular, with a single median furrow, and more or less rounded ends, generally binately connected; valves not carinated. The filaments are more or less interrupted at their margins, and the junction-surfaces are not denticulated.

3 * *Aulacosira.*—Joints cylindrical, bisulcate, with more or less rounded extremities. The genus Aulacosira was proposed by Mr. Thwaites for "those species characterized by the absence in the frustule of an evident central line indicating the place of subsequent fissiparous division, but each frustule having two somewhat distant sulci or fossulæ passing round it." We have found the sulci constant; but Professor Smith believes "the characters have no real existence, and owe their apparent presence in the species Mr. Thwaites adopted as his type, viz. *Melosira crenulata*, Kütz., only to accident, or observation under imperfect illumination. A careful study of the specimens from Aberdeen, upon which Mr. Thwaites himself founded his remarks, and of gatherings from various other localities, has failed to satisfy" him "that any essential differences exist between this species and other Orthosiræ."

4 * *Orthosira.*—Joints exactly cylindrical, marked by a central line, connected into an uninterrupted cylindrical filament; internal cavity often spherical or subspherical (Thwaites). Orthosira contains "those species the frustules of which are not at all convex at the extremities, and which therefore form, by their close contact, an uninterrupted cylindrical filament" (Thwaites). Professor Smith distributes the species of Melosira under two genera, Melosira and Orthosira, which he thus defines. Melosira: "Filaments cylindrical, of numerous frustules, attached or free; frustules spherical or subcylindrical, more or less convex at the junction-surfaces." Orthosira: "Filaments cylindrical, of numerous frustules, continuous, attached or free; frustules and valves cylindrical; junction-surfaces plain, line of junction usually spinous or denticulated." We regret that in the present state of our knowledge we cannot adopt Orthosira as a substantive genus. Its junction-margins, indeed, are usually denticulate or spinous, a character we do not find in Melosira as defined by Professor Smith; but this character is not considered essential. In our opinion, too, there is greater affinity between "*Melosira distans*" and "*Orthosira orichalcea*" than between the latter and "*Orthosira sulcata.*" Melosira is of peculiar interest, as it affords the most frequent examples of that form of reproduction in which the valves of a frustule separate, and a sporangium is formed between them, unattended by conjugation.

* *Frustules encircled with median and lateral ridges.* Lysigonium.

MELOSIRA *nummuloides* (Dillwyn, Ag.).—Frustules spherical, very finely punctured; valves carinated. SBD. ii. p. 56, pl. 49. f. 329.=*M. discigera*, Ag. Marine and brackish waters. Europe, America. (v. 64. XI. 14.) Diam. 1-1700″ to 1-860″. Frustules globular, united in pairs, forming a moniliform filament; each divided into hemispheres by a central ridge and crossed by fainter lines at each end. Professor Kützing describes it as of a golden colour when dry; our specimens are greenish. Sporangial frustules larger, concatenated, originating from the terminal frustule only. According to Kützing, the frustules in this species are ternately, and in the next binately conjoined; this does not coincide with our experience. The only species likely to be confounded with it is the following.

M. *salina* (K.).—Smaller; valves of the binate frustules achromatic, smooth; keels very fine. KB. p. 52, pl. 3. f. 4. = *Gallionella nummuloides*, El. p. 167. *β. concatenata*, more distinctly stipitate; frustules concatenated by a distinct isthmus, KB. pl. 3. f. 5. Brackish waters. Europe. This species differs from *M. nummuloides* by its less conspicuous keels and more distinct stipes. Professor Smith unites them; for "forms aberrant in these respects are so frequently intermixed with the ordinary frustules that" he "cannot regard such peculiarities as of specific importance."

M. *Westii* (S.). — Frustules subglobular; valves conical, with truncated apices and a sutural and median silicious ring. SBD. ii. p. 59, pl. 52. f. 333. Stomach of Pecten, coast of Sussex. This species seems distinct in the strongly marked central and lateral ridges.

2 * *Joints binately or ternately conjoined; valves with rounded ends, neither carinated nor denticulated.* Gallionella.

M. *moniliformis* (Müll., Ag.).—Joints rather longer than broad, finely punctated, binately conjoined, with rounded ends. KB. pl. 3, f. 2. = *M. Borreri*, Gr.; *Gallionella moniliformis*, E. Common in brackish and marine waters. Diam. 1-860″. Kützing describes this species as having ternately conjoined frustules concatenated by a distinct isthmus. Sporangial frustules larger, concatenated, and, according to Professor Smith, originating only in the terminal frustules of the filament. (v. 71.)

M. *lineata* (Dillwyn, Ag.). — Joints cylindrical, smooth, binately conjoined, with rounded ends; pairs closely adnate. KB. p. 53, pl. 3. f. 1 = *Gallionella lineata*, E. Marine. Europe. A single filament sometimes consists of from 1200 to 4000 frustules, forming a chain 2 or 3 inches in length. Length of joint 1-1400″ to 1-430″.

M. *dubia* (Kütz.). — Smaller; articulations depressed, spheroidal, smooth. KB. p. 53, pl. 3. f. 6. Marine, near Cuxhaven. Diam. 1-1200″.

M. *Jurgensii* (Ag.).—Slender; joints smooth, elongated, with two slight constrictions beneath the silicious sheath; junction-surfaces convex, hemispherical, closely concatenate. KB. p. 54, pl. 2. f. 15. = *M. subflexilis*, SBD. pl. 51, f. 331. Brackish waters. Europe. Diam. 1-800″ to 1-1200″. There is only one sutural line, having usually on each side of it a slight constriction. As in *M. varians*, the inflated joints are interstitial, and closely united to the parent frustule. *M. Jurgensii* differs from *M. subflexilis* in its marine habitat and more closely connected joints; but we find it difficult always to discriminate them. The joints are more uniform than in *M. varians*, usually longer in proportion to their breadth, and with more-rounded ends, especially in the new-formed valves. (v. 63.)

M. *subflexilis* (K.).—Frustules cylindrical, smooth, binately conjoined, younger ones elongated, adult shorter, depressed ends slightly convex; pairs united by a short isthmus. KB. p. 53, pl. 2. f. 13. Rivulets. Europe. Diam. 1-560″. Resembles *M. varians* with the binate frustules connected by short interstitial processes. Professor Smith thinks this species identical with *Conferva lineata*, Dill. Sporangial frustules as in *M. moniliformis*.

M. *varians* (Ag.).—Joints cylindrical, irregularly binately conjoined; ends flat with rounded angles, closely adnate; disc with very delicate, radiating marginal striæ. SBD. pl. 51. f. 332 = *Gallionella varians*, Ehr. Fresh water; everywhere common. *β. æqualis*, all the joints quadrate; *M. æqualis*, Ag. This species varies much, both in size and length of joints; the margins of the filament are more or less interrupted; but the geminate arrangement of the frustules is often very obscure; the valves, although, as in most other Diatoms, they are really dotted, appear smooth unless magnified. The sporangial cells are inflated and interstitial; Professor Smith describes them as at first globular, but afterwards dividing (as in the preceding species) and becoming cylindrical, whilst Rabenhorst gives a completely different account of them. The latter says "that on formation of the inflated cell, its granules, at first irregularly formed, become oblongo-ovate. Motion takes place as in ordinary zoospores. The cell opens, the granules stream forth, and two elongated cilia become visible at their hyaline smaller end. Their movement lasts for a very short period; they settle down, and quickly equal or surpass in size the mother-cell." If this description be correct, it will add an important fact in support of their vegetable nature. Professor Smith makes the following diagnostic remarks upon this species:—"The only species with which this form can be confounded is *M. subflexilis*; but *M. varians* has the extremities of its frustules closely applied and partially truncate; those of *M. subflexilis* are often more or less separated by a mucous cushion, and distinctly convex. . . . *M. subflexilis*, when in abundance, appears as a dark-green iridescent mass. *M. varians* always presents a rich golden-yellow or chestnut to the eye. The geminate arrangement of the frustules is conspicuous in *M. subflexilis*, and indistinct in *M. varians*." SBD. ii. p. 58. The fossil frustules of this species constitute the greater part of the earthy deposits of white powder used in polishing silver plate. (IV. 32; IX.* 131; XV. 32.)

3 * *Frustules cylindrical, bisulcate, with rounded junction-margins.*

M. *distans* (E., K.). — Slender; joints cylindrical, smooth or indistinctly punctated, with two distant, delicate, ring-like furrows, all closely connected; disc plane. KB. p. 54, pl. 2. f. 12. Fresh water. Europe, Asia, Australia, Africa, and America. Fossil, Bilin, &c. Diam. 1-3456″ to 1-864″. Joints once to twice as long as broad.

M. *nivalis* (S.).—Joints subcylindrical; valves subhemispherical, distinctly cellulate; extremities more or less truncate; disc dotted. SBD. ii. p. 58, pl. 53. f. 336. = *Coscinodiscus minor*, SBD. i. p. 23, pl. 3. f. 36. Fresh water in Alpine districts. Britain. According to Professor Smith, this form hardly differs from *M. distans*, except in the greater distinctness of the cellules, and may not be distinct.

M. *orichalcea* (Mertens, K.).—Slender; joints obscurely punctated, mostly longer than broad, closely binately conjoined, with slightly crenulate ends and two median furrows; disc plane. KB. p. 54, t. 2. f. 14. = *Gallionella aurichalcea*, Ehr Inf. Fresh water. Common. Europe, Asia, Africa, and America. Younger joints two or three times as long as broad; older ones shorter. This species differs from *M. Italica* merely in its more obscure crenations and apparently smooth disc; and perhaps Professor Smith rightly united them. Its flat and closely connected ends distinguish it from *M. varians*. (v. 65; VIII. 33.)

M. *Italica* (E., K.).—Slender; joints cylindrical, longer than broad, with denticulated ends and two median furrows; disc with striated border. KB. p. 55, pl. 2. f. 6. = *Gallionella Italica*, Ehr.; *G. crenata*, EM. many figures; *G. crenulata*, EA. pl. 2. 1. f. 14; *Melosira orichalcea*, Ralfs, Annals, xii; *Aulacosira crenulata*, Thwaites; *Orthosira orichalcea*, SBD. ii. p. 61, pl. 53. f. 337. Fresh water. Europe, Asia, Australia, Africa, and America. (XI. 29, XV. 33.) β. *Binderana*, Kütz., more slender; joints four to eight times as long as broad, often inflated; disc striated, KB. pl. 2. f. 1. Hamburgh. Mr. Thwaites describes the sporangium as orbicular, with its axis of elongation at right angles to that of the frustule from which it originated; but Professor Smith's experience did not enable him fully to confirm Mr. Thwaites's observations.

M. *coarctata* (E.).—Joints smooth. Its habit is that of *M. varians*, but its disc is not striated. EA. pl. 3. 5. f. 9. Mexico. (XI. 20 & 27.) Kützing unites this form with M. *orichalcea*.

M. *Roseana* (Rab.). — Joints longer than broad, with two broad constrictions and dentated truncate junction-margins; disc with radiating striæ and three or more central dots. Rab D. p. 13, t. 10. = *Orthosira spinosa*, SBD. ii. p. 61, pl. 61. f. 386. Europe. Caves, in moss, on trees, &c.; probably common. Much as they differ in appearance, the late Professor Gregory considered that he had traced the *Lysarogyra spiralis* into this species; and certainly the two forms are almost invariably found together. (v. 67.)

M. *lævis* (E.) = *Gallionella lævis*, EM. pls. 9, 14 & 33. Ehrenberg gives upwards of fifty habitats in Australia, Asia, Africa, and America. His figures of this species differ considerably from each other, and, in the absence of description, render it difficult to form any idea of the specific characters. Ehrenberg (*l. c.* p. 118) says it is allied to *Stephanodiscus Epidendron*, and we strongly suspect that both these forms ought to be united to *M. Roseana*.

M. *pileata* (E., K.).—Joints shorter than broad, smooth, with two finely punctated, widely separated sutures. Junction-portions convex, smooth, often narrower than the intermediate portion (cingulum); hence the hat-like form. KSA. p. 31. = *Gallionella pileata*, ERBA. 1844; M. pl. 35 A. 21. f. 11. Antarctic Sea. Diam. 1-648″.

4 * *Joints cylindrical, connected into an uninterrupted filament; internal cavity often spherical or subspherical.*

M. *arenaria* (Moore). — Filaments stout, curved; joints cylindrical, mostly shorter than broad, closely united with denticulated junction-margins and a line of puncta on each side of suture; disc with radiating striæ and punctated centre. Ralfs, ANH. xii. pl. 9. f. 4. = *Orthosira arenaria*, SBD. ii. p. 59, pl. 52. f. 334; *Gallionella biseriata*, EM. pl. 15 A, f. 5–7. Fresh water. Europe. Easily recognized by its great size. (VIII. 17.)

M. *undulata* (E., K.). — Stout; joints longer than broad, constricted within the sheath, hence undulate; disc slightly convex, very finely radiated. KSA. p. 29. = *Gallionella undulata*, EM. pl. 11. f. 2, 3. Europe and Africa. Professor Smith refers this form to *M. arenaria*.

M. *punctigera*. = *Gallionella punctigera*, EM. pl. 12. f. 9. Fossil. Germany. Ehrenberg's figure represents a large species, perhaps not distinct from *M. arenaria*. Joints within a common sheath, in one figure shorter, in another longer than broad, constricted on each side of the suture, and having a series of dots along the junction-margins. Disc with numerous radiating dotted lines and a smooth umbilicus.

M. *Sol* (E., K.). — Joints coin-like, five times shorter than broad; disc plane, large, strongly and broadly radiated, with a smooth umbilicus and narrow smooth rim. KSA. p. 31. = *Gallionella Sol*, EM. pl. 35 A. 22. f. 12. Antarctic Sea. Rays 84; suture of valves single. Diam. 1-336″. This species rivals *M. arenaria* in size, and somewhat resembles it in appearance, but is marine.

M. *Oculus* (E., K.).—Habit of *M. Sol*, but larger, with equal and stouter rays. KSA. p. 31. ERBA. 1844, p. 202. Antarctic Sea. Rays 67. Diam. 1-240″. Probably a state of *M. Sol*.

M. *Tympanum* (E., K.). — Disc very broad, with a smooth centre and a narrow, finely striated margin. KSA. p. 31; ERBA. 1844, p. 202. Antarctic Sea.

M. *calligera* (E., K.). — Joints small, smooth, having the habit of *M. distans*, but with a single median suture and an enclosed, double, granular mass (as in *M. undulata*). KSA. p. 31. = *Gallionella calligera*, ERBA. 1845; EM. pl. 12. f. 9 *k, l*. Fossil in pumice, Island of Ascension. Diam. 1-1728″.

M. *sculpta* (E., K.). — Joints not so long as broad, densely striated, and elegantly sculptured with horizontal punctated lines; suture a narrow smooth band; disc with radiating punctated lines. KSA. 31. = *Gallionella sculpta*, EM. pl. 33. 12. f. 20, 21. Fossil. Oregon. Diam. 1-960″. Frustules oval.

M. *Campylosira*. = *Gallionella Campylosira*, EM. pl. 35 A. 13 B. f. 1–3. Elbe. Resembles *M. sculpta*, but smaller. Joints suborbicular, within an uninterrupted sheath, with horizontal dotted lines on each side of a narrow, smooth sutural interspace; disc with marginal radiating lines.

M. *Californica* (E.). — Joints broader than long, densely and strongly striated with horizontal punctated lines; sutural interval smooth, not distinct. = *Gallionella Californica*, ERBA. 1852, p. 534. Fresh water. California. Very much akin to the fossil *M. sculpta*, and both forms closely approach *M. granulata*. Frequently the granulated, dome-shaped terminal discs are found dispersed amongst the truncated joints. Perhaps therefore this form, with *M. Horologium*, should be referred to the peculiar genus Sphærotermia.

M. *Horologium* = *Gallionella* vel *Sphærotermia Horologium*, EM. pl. 33, 2. f. 17. Fossil. Siberia. We have seen no description of this species, or of Ehrenberg's genus, Sphærotermia. Frustule with horizontal striæ interrupted by the smooth sutural band; disc with a large, definite, smooth umbilicus and distant radiating striæ, terminating at inner ends in a circlet of gland-like dots (tubercles?). (V. 62.)

M. *arctica* (Dickie). — Joints globose or oval, smooth, the median sutural line generally single, but duplex in subcutaneous division, with a smooth band interposed. = *Gallionella arctica*, ERBA. 1853, p. 528; EM. pl. 35 A. f. 1, 2. Melville and Kingston Bays. In Ehrenberg's figures the frustules are within a common continuous sheath, and marked with horizontal series of puncta.

M. *sulcata* (E., K.). — Joints shorter than broad, with a smooth median furrow and pinna-like cellules on each side; disc furnished with radiating striæ, which do not reach the centre. KB. p. 55, pl. 2. f. 7. = *Gallionella sulcata*, Ehr.; *Orthosira marina*, SBD. ii. p. 59, pl. 53. f. 338. Marine. Frequent, both recent and fossil. (IX. 131 and XI. 26.) This species, which varies considerably in size, is well marked by its short, slightly angular joints, and its transverse sculpture-like marks on each side of the suture. Margin of disc often denticulate. Diam. 1-860″ to 1-600″.

M. *coronata* (E., K.).—*M. sulcata* in habit; joints cylindrical, striated; disc smooth, slightly convex, with a crenated margin and a circlet of pearl-like granules within. KSA. p. 31. = *Gallionella coronata*, EM. pl. 38. 22. f. 5. Marine. Asia, Africa, Patagonia. Diam. 1-864″. It differs from *M. sulcata* only in the more distinct crenations of the disc and the circlet of dots.

M. *plana* (E., K.).—Habit of *M. sulcata*; but disc plane, smooth, and neither radiated nor granular. KSA. p. 31. = *Gallionella plana*, ERBA. 1845. Fossil. Patagonia. D. 1-1152″. This form may possibly be *M. sulcata*, with its markings destroyed by igneous action.

M. *Hetrurica* (K.). — Small; joints cylindrical, smooth, twice as long as broad, with finely denticulated junction-margins; disc convex, marked with dotted rays. KB. p. 55, pl. 2. f. 6. Fossil. San Fiore. Diam. 1-3600″ to 1-800″.

M. *granulata* (E.).—Joints longer than broad, with horizontal punctated lines on each side of the median suture, and denticulated junction-margins; disc with a series of marginal puncta. = *Gallionella granulata*, EA. p. 123; M. many figures; *G. tenerrima*, EM. pl. 39. f. 50; *Orthosira punctata*, SBD. ii. p. 62, pl. 53. f. 339. Fresh water. Ehrenberg gives upwards of 50 habitats in Europe, Asia, and America.

M. β. *maxima*. Disc with 31 marginal denticulations, and strongly akin to *M. sulcata*.

M. *Marchica* (E.). — Resembles *M. granulata*; but the dotted lines are parallel to the suture, and not horizontal. = *Gallionella Marchica*, EM. several figures; *G. procera*, EM. pl. 15 A. f. 1. Fresh water. Europe, Asia, Africa, and America.

M. *decussata* (E.). — Resembles *M. granulata*; but the dotted lines are diagonal and decussating. = *Gallionella decussata*, EM. several figures. Fresh water. Asia, Africa, and America. Kützing includes, perhaps correctly, *M. Marchica* and *M. granulata* under this species.

M. *lirata* (E., K.).—Has the habit of *M. granulata*, but with more conspicuous lines, disposed like the strings of a lyre. KSA. p. 31. = *Gallionella lirata*, EM. pl. 2. 3. f. 33. Fossil. America.

M. *spiralis* (E., K.).—Filaments curved and spiral; joints small, oblique, longer than broad, or equal, loosely punctated in transverse series. KSA. p. 31. = *Gallionella spiralis*, EM. pl. 33. 13. f. 3. Fossil. Oregon. Diam. 1-2304″.

M. *Americana* (Kütz.).—Frustules included in a jointed cylindrical tube, separated by dissepiments of the tube, elliptic, with striated margins and a median furrow; disc with radiating striæ, convex. KB. pl. 30. f. 69. = *Orthosira Americana*. Diam. 1-660″. Apparently furnished with internal silicious cells.

M. *Dickieii* (Thwaites, K.). — Joints mostly longer than broad, smooth or obscurely punctated, except by conspicuous dots bordering the suture; disc obscurely punctate; sporangia? fusiform. KSA. p. 889. = *Orthosira Dickieii*, Thwaites, ANH. 2nd series, i. pl. 12; SBD. ii. p. 60, pl. 52. f. 335. Fresh water. Cave near Aberdeen. (XV. 29.) "The filaments of this beautiful species consist generally each of from two to four frustules, which are hyaline and perfectly smooth; central cavity filled with dark red-brown endochrome; sporangium fusiform, marked with numerous annular constrictions, whose formation is progressive, and which go on increasing until the sporangium is fully developed (XV. 296. 29 B. a filament, the terminal cells of which have each commenced to develope a sporangium; and f. 29 C. a mature sporangium). This formation thus occurs: at the commencement of the formation of a sporangium, the endochrome, at the same time that it withdraws from the end of the frustule, produces at its centre an additional ring of cell-membrane; and, this process continuing to take place at certain intervals, each new ring of cell-membrane exceeding in diameter those previously formed, produces at length the structure represented in f. 29 C; or it may be a more correct explanation of the process to say that an entire new cell-membrane has been developed by the young sporangium at the time each new ring has been formed, and that thus have originated the several chambers into which the ends of the sporangium are divided; fissiparous division subsequently takes place, and sporangial frustules are developed from each half, as shown in f. 29 D." Professor Smith doubted whether the fusiform bodies are sporangia, as "this mode of development, in the formation of sporangia, stands alone and unsupported — a serious difficulty in the way of admitting Mr. Thwaites's conclusions." For this and other reasons, he was disposed to refer the process to the development of internal cells, as in Meridion, Himantidium, Odontidium, and Achnanthes, and recorded his impression that the process was not connected with the sporangia.

M. *tenuis* (K.).—Very slender; joints cylindrical, smooth, longer than broad, closely connected, produced at their junction. KB. p. 54, pl. 2. f. 2. In the polishing powder of Luneberg. Diam. 1-5760″.

M. *Garganica* (Rab.).—Very slender; joints two or three times as long as broad, with stout, protuberant, indistinctly dentate junctions; disc flat, punctated on the periphery. Rab D. p. 14, t. 2. f. 8. Italy. After burning, it reminds one of *M. tenuis.*

Doubtful and imperfectly described Species.

M. *Dozyana* (Van den Bosch).—Joints cylindrical, finely punctated; length equal to or a little longer than the breadth. KSA. p. 29. Stagnant water. Holland. Diam. 1-1152″ to 1-770″.

M. *circularis.* = *Gallionella circularis.* EM. pl. 35 A. 9. f. 3. Asia and America. Filaments slender, curved; joints broader than long, closely connected, smooth, with a single sutural line.

M. *Gallica.* = *Gallionella Gallica,* EM. pl. 9. 2. f. 2. Fossil. France. The frustule has one diameter twice as long as the other, and no suture or striæ.

M. *halophila* = *Gallionella halophila,* EM. pl. 37. 5. f. 1. Europe. Frustules minute, smooth.

M. *tæniata* = *Gallionella tæniata,* EM. pl. 39. 3. f. 65. Atmospheric dust. The figure shows a single subquadrate frustule, without any distinguishing character.

M. *trachealis* = *Gallionella trachealis,* EM. pl. 8. 2. f. 18. Hungary. Ehrenberg's figure is too imperfect to be intelligible.

M. *laminaris* = *Gallionella laminaris,* EM. pl. 39. 3. f. 64. Asia. The imperfect figure shows striated junction-margins.

M. *Scala* = *Gallionella Scala,* EM. pl. 8. 1. f. 24. Hungary. The figure represents a slender continuous filament, divided into smooth quadrate joints.

M. ? *mesodon* = *Gallionella*? *mesodon* (*Fragilaria mesodon*?), EM. pl. 11. f. 16. Bohemia. Filament slender, continuous, with smooth subquadrate joints, having two puncta at each outer margin, as in Fragilaria.

M. *ochracea.* = *Gallionella ferruginea* (Ralfs).—Slender, oval, convex at both ends; smooth. In many, perhaps in all chalybeate waters, and also in peat-water, which contains a small proportion of iron, this is to be found; it is of the colour of iron-rust, and in mineral springs, in which it abounds, is often taken for precipitated oxide of iron. It covers everything under water, but forms so delicate and floccose a mass, that the least motion dissipates it. In the spring of the year, this mass is composed of very delicate pale-yellow globules, which can be easily separated from each other. They unite together in rows, like short chains, and produce an irregular gelatinous felt or floccose substance. About summer, or in autumn, they become developed into more evidently articulated and stiff threads, of a somewhat larger diameter, but still form a complicated mass or web, and, either from adhering to each other or to delicate Confervæ, appear branched; in the young condition, when examined under shallow magnifiers, they resemble gelatine; but with a power of 300 diameters, the flexible granules are discoverable, and, with dexterous management, the little chains forming the felt or floccose web can be made out. In summer, on the other hand, its structure can be observed much more easily and distinctly. Early in spring, the colour is that of a pale yellow ochre; but in summer, that of an intense rusty red. Diam. 1-1200″.

According to Kützing, this is not a species of Gallionella, but a Conferva; it has no true silicious lorica, as have true Diatomeæ; and the coating of oxide of iron is not an essential element, but merely an incrustation, such as will form on well-known Confervæ placed under like circumstances, *i. e.* in water holding salts of iron in solution, which are subsequently precipitated by exposure to the air, and converted into the red oxide.

The same author differs from Ehrenberg as to the part played by the so-called *Gallionella ferruginea* in the production of the oxide of iron in chalybeate waters, of bog-iron ore, of clay-iron ochre, &c. For, he observes, in many springs rich in iron no such organism is found, although other Confervæ may be present — Confervæ, however, not peculiar to such habitats, but common in springs and ponds generally.

Mr. Ralfs (*op. cit.* p. 352), however, in part supports Ehrenberg, declaring that, though identical with *Conferva ochracea* (Dillwyn), yet "Ehrenberg is no doubt correct in placing the plant in this genus, as the filaments are silicious and cylindrical."

Nägeli describes and figures a species which he refers to the genus Gallionella; but it is a doubtful member. His description, however, especially that of the self-division, induces us to give it nearly in his own words, with his name (Ray Society, 1846, p. 219).

M. *Nägeli* (R.).—Shortly cylindrical; diam. ·014‴ to ·027‴. Marine. Naples.

"Both the terminal surfaces of the cylinder are flattened; so that, when seen sideways, it appears rectangular, with the angles rounded off. It is composed of one simple cell, whose membrane is covered by a siliceous plate; and its cavity contains chlorophyll-granules, which lie upon the membrane in two circular bands. (xv. 26–28.) Each of these bands occupies one of the obtuse angles of the cylinder, and appears annular from above, rectilinear from the side.

"In developing, the relative length of the cylinder increasing, a septum divides it into halves (xv. 28 *c*), which when complete, the latter separate as two distinct beings. The nascent chlorophyll-granules are either spread equally over the surface, or more frequently arranged in radii from the nucleus in the centre; they lie in the course of the currents streaming from the nucleus. Compared with a cell of Conferva, or of Spirogyra, all three agree in the forming of a septum, in the similarity of their contents, and in the depositions of extra-cellular substance. But Gallionella differs from both, by the production of an individual from every cell, also by the chlorophyll forming two lateral bands, and the siliceous extra-cellular substance an intermediate one.

"So far as my investigations go, Gallionella, which, according to Ehrenberg, possesses a bivalved or multivalved shield, agrees with the above-described plant in all essential particulars. The lines, for instance, which would intimate a division of the shell into two or more pieces, are the septa by which the cell-division is effected. As in the filiform Algæ, these walls at first appear as delicate lines; then, by an increase of thickness, seem two clearly defined lines; and at last present themselves as two lamellæ, separated by an intermediate third line. The perforations which Ehrenberg described, I look upon as nothing more than intercellular spaces, formed between the two new-formed cells and the parent cell. These so-called perforations are only visible, therefore, on the two lateral borders where the wall abuts upon the membrane. The Confervoid Algæ exhibit a similar appearance."

Gallionella (?) *Novæ Hollandiæ* (Ehr.), Avon River, Australia; *G. gibba* (Ehr.), fossil, Georgia; *G. punctata* (Ehr.), Western Asia; *G. tincta* (Ehr.), Ural Mountains; *G. gemmata* (Ehr.), Siberia; *G. lineolata* (Ehr.), fossil, North Asia; *G. undata* (Ehr.), Himalaya Mountains; *G. curvata* (Ehr.), India; *G. vaginata* (Ehr.), India; *G. Nilotica* (Ehr.), River Nile, are species known to us only by name.

Genus ARTHROGYRA (Ehr.).—The characters of this genus are unknown to us; but, judging from Ehrenberg's figures of the species, it seems to have been constituted for the reception of those forms of Melosira which, like *M. Dickieii*, produce horizontal, elongated, tapering internal bodies or sporangia.

ARTHROGYRA *Guatimalensis*, EM. pl. 33. 6. f. 1. Fern-earth. Guatemala.—Filament straight, jointed, with crenated margin, and straight, fusiform internal body.

A. *semilunaris*, EM. pl. 33. 6. f. 2. Guatemala.—Filament jointed, curved, with crenate margins, and semilunate internal body.

Genus DISCOSIRA (Rab.).—Frustules united into a short filament, with a thick mucous covering; in lateral view circular, having a uniformly punctate centre, a border of numerous (24 to 33) slightly curved, oblique, ray-like lines, and a marginal crown of teeth (50 to 64).

DISCOSIRA *sulcata* (Rab.).—Frustules in front view with deep transverse furrows, which correspond to the teeth of the lateral surface. Rab D. p. 12, t. 3. In a lagoon at Manfredonia, east coast of Italy. Each tooth is minutely denticulate, but requires the highest magnifying powers to ascertain it. (v. 68.)

Genus LIPAROGYRA (Ehr.).—Frustules simple, cylindrical, each having an internal spiral filiform band or crest.

The habit of this genus closely resembles that of Spirogyra, a non-silicious genus of Algæ.

LIPAROGYRA *dendroteres* (E.). — Frustules smooth, crystalline, three or four times as long as broad, with an internal spiral band; margin of disc denticulated. Rab D. p. 12. = *L. spiralis*, EM. pl. 34. 5A. f. 1, 3. On trunks of trees. Venezuela. Thirteen spirals in 1-360″. (v. 72.)

L. *circularis* (E.).—Frustule with 13 annular turns of internal line in 1-360″. Rab. *l. c.* p. 12. With the preceding, and in Brazil. Ehrenberg says he is not satisfied whether the preceding are distinct species, or merely varieties. Each has a smooth disc, with three central apiculi.

L. *scalaris*, EM. pl. 34. 5A. f. 2. South America. Ehrenberg's figure represents the frustule in front view as divided by cross bars in a ladder-like manner.

Genus POROCYCLIA (Ehr.).—Resembles Liparogyra, but is without spires, has interior circular rings, and the margin of its disc-like ends a circlet of deep impressions. We doubt whether this genus is sufficiently distinct from Liparogyra.

POROCYCLIA *dendrophila* (E.). — Frustules smooth, with 9 annular lines; disc with 12 marginal depressions, radiating series of puncta, and 5 central apiculi. Rab D. p. 12. On trunks of trees. Venezuela. L. 1-320″; w. 1-560″.

Genus STEPHANOSIRA (E.).—Frustules united into a short filament; disk with radiating series of minute puncta, and a marginal crown of teeth. In form this genus resembles Stephanodiscus, but differs from it, and becomes allied to Melosira by its imperfect spontaneous division, and consequent concatenation. In Melosira, however, the circlet of spines is wanting. We are unacquainted with this genus; and its characters scarcely suffice to distinguish it from Orthosira. All the known species are found on trees.

STEPHANOSIRA *Epidendron* (E.). — Front view with punctated transverse lines and furrow. Rab D. p. 14. On trees. Venezuela and Brazil. Larger diameter 1-432″; smaller 1-4320″.

S. *Hamadryas* (E.). —In front view smooth, but with junction-margins striated; disc having marginal radiating puncta, and its centre a few scattered dots. Rab. *l. c.* p. 14. On trees with the preceding species. Diameter 1-720″.

S. *Europæa* (E.). —Frustules often broader than long, smooth, but with very faintly striated junction-margins. Rab. *l. c.* p. 14. Among mosses on trees at Berlin. Much smaller than the preceding. Chain formed of three to four frustules, each 1-2304″ to 1-1152″ in depth; rarely 1-1200″ in width.

Genus STEPHANODISCUS (E.).—Disc with radiating series of punctiform granules, and furnished with a crown of erect marginal teeth. Aquatic. Stephanodisci approximate in character to Cyclotella, but differ from them by the circlet of teeth. They also approach closely to the non-cellulose Coscinodisceæ, and seem to have as good a claim to rank with that family as with the Melosireæ. Stephanodiscus differs from Odontodiscus in the same manner as Peristephania does from Systephania, and in our opinion might, without inconvenience, be united to it.

STEPHANODISCUS *Berolinensis* (E.). —Small, discoid; disc plane, finely radiated, and furnished with acute marginal teeth (often 32) on each side. KSA. p. 21. Alive, Berlin. Diam. 1-1152″. Internal granular substance brown, lobed.

S. *Ægyptiacus*, EM. pl. 33. 1. f. 16. Egypt. Ehrenberg's figure represents the disc with series of puncta radiating from the centre, without a distinct umbilicus, the teeth numerous, subulate, and erect. (v. 69.)

S. *Sinensis*, EM. pl. 34. 7. f. 7. Canton. Ehrenberg's figure shows the puncta arranged as in *S. Ægyptiacus*, but the rim striated, and the teeth nodule-like and intra-marginal.

S. *Bramaputræ*, EM. pl. 35 A. f. 9, 10. Ganges. Puncta as in the foregoing species, the rim furnished with short triangular teeth.

S. *Niagaræ* (E.).—Frustules small; disc with numerous (often 64) series of punctiform granules radiating from a large granulated umbilicus, and as many acute marginal teeth as rays. EM. pl. 35 A. 7. f. 21, 22. Niagara. This species is distinguished by its granulated umbilicus.

Genus PERISTEPHANIA (Ehr.).—Frustules simple, discoid; disc with decussating parallel series of granules, and numerous marginal teeth. Maritime. "The characters of this genus so well agree with Stephanodiscus that perhaps we might more correctly refer the deep-sea form to that genus. But as the hitherto known Stephanodisci are all fluviatile, and the maritime form in the order of its cellules very nearly approaches the purely maritime *Coscinodiscus lineatus*, I have preferred not mixing fluviatile Stephanodisci with a doubtful maritime form. Perhaps the flow in deep water may have commingled a fluviatile form with the maritime ones. Should, therefore, a similar form be hereafter found in any river, this generic name must be cancelled, and the form placed in Stephanodiscus" (ERBA. 1854, p. 236). As we consider habitat altogether inadmissible as a generic distinction, we would distinguish Stephanodiscus and Peristephania by the radiating granules of the former, and their parallel arrangement in the latter genus. We should prefer to unite this genus with Systephania, which differs only in having intra-marginal teeth. Perhaps even *Coscinodiscus lineatus* might be included, thus making the parallel arrangement of the granules the essential character.

PERISTEPHANIA *Eutycha* (E.).—Habit of *Coscinodiscus lineatus*; margin of the disc armed with numerous erect, crowded teeth. EM. pl. 35 B. 4. f. 14. Deep soundings of the Atlantic. (v. 73.)

P. *lineata* (E.).—Resembles *P. Eutycha*, but its teeth are fewer and more distant. EM. pl. 33. 13. f. 22. Californian deposit and guano.

In both species the teeth are minute and triangular.

Genus PYXIDICULA (Ehr.).—Frustules simple or binately conjoined, free or adnate, bivalved; central portion obsolete; valves very convex. In Pyxidicula the frustule forms a bivalved box, and differs from Cyclotella in its vaulted valves and the absence of an interstitial portion. The same characters distinguish it from all the Coscinodisceæ. As first constituted by Ehrenberg, Pyxidicula contained very heterogeneous forms; by the formation, however, of Mastogonia, Stephanogonia, Stephanopyxis, and Xanthiopyxis as distinct genera, this defect has been in a great measure removed; but we believe it still includes some doubtful species. Dictyopyxis was separated by Ehrenberg, first as a subgenus and afterwards as a genus, for those forms characterized by the cellulose structure of the valves, leaving in the original genus the smooth and punctated species. We have thought it more desirable to regard Dictyopyxis as a subgenus only, until some of the species are more fully known.

* *Frustules smooth or minutely punctate.* Pyxidicula.

PYXIDICULA *operculata* (E.).—Frustules small, orbicular, hyaline, punctated. EM. pl. 16. 1. f. 46. = *P. minor*, KSA. p. 21. Fossil, Sweden; recent, Asia, England? Diam. 1-1440″ to 1-570″. Valves joined by a distinct suture. Kützing refers *P. operculata* (E.) to Cyclotella.

P. *Adriatica* (Kütz.).—Adnate, sessile, of middle size; valves convex, nearly hemispherical, very smooth. KB. t. 21. f. 8. Adriatic. (XIII. 33.) Diam. 1-600″.

P.? *prætexta* (E.).—Valves geminate, slightly hispid, neither cellulose nor radiated, but bordered by a raised limb; middle flat. KSA. p. 22. Fossil. Greece. Diam. 1-1152″.

P.? *urceolaris* (E.).—Valves geminate, unequal, urceolate (the one more convex, elongated, the other shorter), each with a plane, raised limb; cellules none, but about ten smooth rays in the longer, and eight apiculate ones in the shorter valve. = *Dictyopyxis urceolaris*, EM. pl. 18. f. 3. Fossil. Virginia. Diam. 1-1728″.

P. *longa* (E.). — Oblong, two and a half times as long as broad, cylindrical, with rounded ends; suture longitudinal. KSA. p.22. Fossil. Virginia. L. 1-1080″.

2* *Frustules cellulose.* Dictyopyxis (*E.*).

P. *cruciata* (E.). — Frustules oblong, with rounded ends; cellules large, arranged in parallel lines; rim distinct. EM. pl. 18. f. 2. = *Coscinodiscus cruciatus*, KSA. p. 125.

β. Hellenica, smaller = *Dictyopyxis Hellenica*, EM. pl. 19. f. 13. Fossil. America. Guano, &c. Frequently the disk has some series of its cellules more conspicuous and forming a cross. Valves campanulate.

P. *Cylindrus* (E.). — Cylindrical, with rounded ends, three times as long as broad; valves with obscure rows of cellules. EM. pl. 33. 13. f. 8. Fossil. Maryland. Diam. 1-960″. Valves campanulate, separated by a suture.

P. *Lens* (E.).—Frustules laterally depressed, lenticular, cellulose; valves in front view semielliptic. EM. pl. 18. f. 5. Fossil. Virginia. Diam. 1-636″. The frustule is oval in the front view, the suture forming the greatest diameter.

P. *areolata* (E.). — Valves with a heptagonal, areolate, punctated centre, and seven lateral punctated areolæ. KSA. p. 22. North America. D. 1-960″.

P. *gemmifera* (E.). — Valves turgid, crystalline, not bordered, furnished with lax series of crystalline nodules, fifteen of which very nearly reach the smooth centre. KSA. p. 22. Fossil. Maryland. Diam. 1-792″.

P. *compressa* (Bail.).—Frustules elliptic, bivalve; valves separated by a plane passing through the longer axis, slightly convex, and with transverse rows of dots. BC. ii. p. 40, f. 13, 14. Florida.

P. *dentata* (E.).—Frustules having the convex margin furnished with (irregular) slightly prominent little teeth; cellules rather large, 6 in 1-1200″. KSA. p. 22. Antarctic Ocean. Diam. 1-840″.

P.? *limbata* (E.). — Frustules oblong, with a central keel; valves showing in front a central cellular surface, and 32 to 40 radiating lines; border not cellulose. = *Stephanopyxis limbata*, EM. pl. 18. f. 7. Fossil. Maryland. D. 1-792″. Ehrenberg's figure is oval, and has a broad, distantly striated, but not cellulose rim, and in its centre scattered granules.

P. *cristata* (E.).—Frustules with geminate, lenticular valves, which are close together, not winged, with a somewhat prominent margin like a thin suture; cellules of disc in rows. = *Stephanopyxis cristata*, EM. pl. 18. f. 6. Fossil. Virginia. Diam. 1-816″. Ehrenberg's figure somewhat resembles that of *P. limbata*; but the cellules of the oval valve are crowded, and the striated rim is narrower.

Obscure or doubtful Species.

P. *Nägelii* (Kütz.).—Smooth, one side orbicular, girt with a membranous winglike ring; the other side oval, one margin more convex, umbonate in the middle. KSA. p. 889. Switzerland.

P. *Actinocyclus* (E.).—Frustules with two flattened, finely cellular and elegantly radiated valves; rays 30 to 40, straight and dense. EM. pl. 18. f. 19. = *Cyclotella Actinocyclus*, KSA. p. 20. Fossil. America. Diam. 1-720″. Ehrenberg figures only the lateral view, which in its radiating series of dots resembles a Coscinodiscus.

P. *Scarabæus* (E.). — Oblong, with unequal valves; when viewed laterally, recalling the figure of the Scarabæus. = *Dictyopyxis Scarabæus*, E. Fossil. Virginia. Diam. 1-648″. Cellules 14 in 1-1150″.

P. *major* (Kütz.). — Frustules large, elliptic, regularly punctated. KB. t. 1. f. 25. North America; France. Diam. 1-420″. Probably a state of *P. cruciata*.

P. *globata*. — We insert under this name certain spherical bodies of a diameter varying from 1-240″ to 1-1150″, discovered in 1836 by Ehrenberg in flints near Berlin, and considered by him to belong to the silicious Diatomaceæ. Kützing has examined these bodies, which occur along with silicious spicula of sponges and species of Xanthidium and Peridinium, but does not consider them Pyxidiculæ. The section of pebble containing these specimens, from which Mr. Bauer's drawings (XVII. 506-509) were made, was found on Brighton beach. The figures are magnified 100 diameters.

P. *prisca*, EM. pl. 37. 7. f. 5. This species is found in flints, and is probably the same as the preceding.

P.? *gigas*, EM. pl. 33. 13. f. 18. Fossil. California. The figure shows a large orbicular disc, with distant scattered dots, and no suture.

P. *decussata* (E.).—Found in the chalk marl of Ægina.

Genus STEPHANOPYXIS (Ehr.).—Frustules simple or united into short filaments, in front view orbicular or oblong, composed of two cellulose valves, each having a crown of teeth, spines, or membrane; central portion obsolete; lateral view circular. "This group includes those Pyxidiculæ which have turgid forms with a cellular surface, bearing in the middle of the valves a crown of small teeth, prickles, or a membrane" (Bailey). The fossil species appear simple; but as recent specimens forming short filaments have been obtained by the Rev. R. Cresswell and Mr. Norman, probably the others also were originally so formed, but, as the crowns prevent the close union of the frustules, they become more easily disconnected. The valves agree in their turgid form, rounded ends, and cellulose structures with Pyxidicula; but their coronets will easily distinguish them.

STEPHANOPYXIS *Diadema* (E.). — Valves hemispherical, with parallel, straight rows of cellules; centre of disc depressed, with a circlet of numerous teeth (20 to 30). = *Pyxidicula Diadema*, KSA. p. 21. Fossil. Virginia; guano. Diam. 1-576″. We have seen two frustules connected.

S. *Turris*.—Frustules cylindrical, cellulose, ends depressed at the centre and furnished with a crown of spines or processes, which are truncate or clavate at their apices; areolæ hexagonal, 7 in ·001″. = *Cresswellia Turris*, Grev. in GDC. p. 64, pl. 6. f. 109. In stomach of Ascidia. Teignmouth, Hull, &c. Fossil in guano. We regret being unable to accept the genus Cresswellia, as we believe all the species of Stephanopyxis, when recent, have the frustules connected by their coronets: *S. Diadema*, a species closely allied to the present, we have found so united in specimens from guano. This character has probably escaped detection only because in all filamentous forms the fossil frustules are usually separated. The coronets of numerous non-attenuated spines distinguish this species. (v. 74.)

S. *apiculata* (E.). — Frustules oblong or subcylindrical, end broadly rounded; cellules not crowded, arranged in longitudinal rows; centre of disc with a few elongated spines, EM. pl. 19. 13. f. 6. America, Europe, guano, &c.

S. *appendiculata* (E.). — Frustules in front view subglobose, coarsely and closely cellulose; segments with rounded ends, each with an excentric, short, hornlike process. EM. pl. 18. f. 4. Fossil. Virginia. Diam. 1-624″. Processes truncate, not central; cellules forming a crenated margin.

S. *turgida* (Grev.).—Front view cylindrical-oblong; junction-margins subtruncate, with rounded angles and a crown of elongated spines with dilated apices; areolæ 11 in ·001. = *Cresswellia turgida*, Grev MJ. vii. p. 165, pl. 8. f. 14. Californian guano. This species is nearly related to *S. Turris*, but differs in the larger, more truly cylindrical and truncate frustules, and in the considerably smaller areolation, Grev.

S. *ferox* (Grev.).—Front view oblong; valves subglobose, campanulate, hispid, with a crown of elongated spines and a thin, hyaline, prominent suture; areolæ large, 5 in ·001″. = *Cresswellia? ferox*, Grev MJ. vii. p. 166, pl. 8. f. 15, 16. Californian guano. The valves are expanded at their junction so as to form a sutural keel, as in some species of Pyxidicula. (v. 75.)

Genus XANTHIOPYXIS (Ehr.).—Valves turgid, continuous, entire, noncellulose, hispid, setose, or winged. = Pyxidicula *olim*. Fossil. "These forms are Pyxidicula with bristles, setæ, or wings. They have the habit of Xanthidium and Chætotyphla, but are bivalved and silicious." The true affinity of this genus is doubtful: we have seen no species which is circular in the lateral view, and consequently consider them misplaced in the Melosireæ:

but, from our insufficient acquaintance with them, we are unable to decide on their proper position, and have not attempted their removal. Are they akin to Goniothecium?

XANTHIOPYXIS *globosa* (E.). — Frustules subglobose, hispid, with short setæ. = *Pyxidicula globosa*, KSA. p. 23. Fossil. Bermuda. Diam. 1-552".

X. *oblonga* (E.). — Frustules oblong, equally and broadly rounded at each end, densely hispid, with short setæ, which are sometimes joined by a membrane. EM. pl. 33. 17. f. 17. = Pyxidicula (K.). Fossil. Virginia. L. 1-552". (v. 76.)

X. *constricta* (E.).—Frustules oblong, constricted at the middle, and broadly rounded at each end, hispid, with short setæ, which are often joined by membrane. = *Pyxidicula constricta*, KSA. p. 23. Fossil. Bermuda. L. 1-384". Differs from *X. oblonga* by its constriction.

X. *hirsuta* (E.).— Frustules bivalved, subglobose, not cellulose, rough with simple and obsoletely forked hairs. = *Pyxidicula? hirsuta*, ERBA. 1845. Fossil. Maryland. Diam. 1-115". Habit of Xanthidium, but silicious.

X. *urceolaris* (E.). — Valve urceolate, with the summit bristly; margin revolute. EM. pl. 33. 16. f. 14. Fossil. Virginia. Diam. 1-1560". "I [Ehrenberg] have only met with single valves. In form they resemble Stephanogonia, but are not angular."

X. *alata* (E.).—Frustules smooth, oblong, each end equally and broadly rounded; margin of the valves bordered by a lacerated or deeply dentate, not setose membrane. = *Pyxidicula alata*, KSA. p. 23. Fossil. Bermuda. D. 1-552".

Doubtful Diatom.

X. *aculeata* (E.) = *Pyxidicula aculeata*. The figure in Microg. pl. 18. f. 124 shows a globular spinous body, resembling some sporangia of the Desmidieæ. Ehrenberg himself regards this as a very doubtful Diatom.

Genus INSILELLA (Ehr.).—Frustules simple, equally bivalved, cylindrical (fusiform), with a turgid ring interposed in the middle between the valves. Marine. Resembles a cylindrical Biddulphia.

INSILELLA *Africana* (E.).—Frustules fusiform, smooth, four times constricted; the middle joint largest, subglobose; the others decreasing at each end, oblong; each apex acuminated. KSA. p. 32. Mouth of the river Zambese, Africa.

FAMILY VIII.—COSCINODISCEÆ.

Frustules disciform, mostly simple; lateral valves or discs flat or convex, cellulose, areolate or granulate, without processes, but sometimes furnished with spines or teeth; connecting zone ring-like and generally smooth. The Coscinodisceæ are closely allied to the Melosireæ,—a fact noticed by Kützing himself, although in his arrangement the families are widely separated. The distinction between them is by no means satisfactory; according to Kützing, it consists in the cellulose or areolated structure of the Coscinodisceæ. But whilst on the one hand we find in the Melosireæ some species of Pyxidicula and Stephanopyxis with cellulose valves, on the other hand, in this family some species are merely granulate or punctate. Practically, however, the proper situation of the species can generally be determined without much difficulty. In the Coscinodisceæ the frustules never form filaments, the connecting zone is always present, narrow and ring-like, and the lateral valves are never so convex as to be hemispherical or campanulate; so that the disk is almost always in the field, it being difficult to obtain a good front view. Most of the forms included in this family are marine, and many are remarkable for their exceeding beauty.

Genus COSCINODISCUS (Ehr.).—Frustules simple, discoid; disc cellular or dotted, without processes, defined border, internal septa, or division into radiating compartments. "The only essential character that distinguishes this genus from Cyclotella is the areolation of the secondary surfaces" (Menog.). "This genus finds its nearest allies in the Melosireæ, whose genera, from their filamentous character, stand widely apart. Were the frustules of *Coscinodiscus eccentricus,* for example, permanently coherent after self-division, it would be difficult to separate them, in a generic point of view, from those of *Orthosira nivalis,* which have the same cellular structure, or from those of *Melosira aurichalcea* or *M. sulcata,* which are furnished with a projecting fringe of silex, the homologue of the spinous processes in *C. eccentricus*" (Smith, BD. i. p. 23). Coscinodiscus is easily distinguished from most genera in this family by a disk not divided into compartments. In the greater number of species the cellules have a radiating arrangement, and become smaller near the margin; the former character, however, is frequently obscure, and is best seen by as low a magnifying power as will suffice to determine the cellular or dotted structure.

* *Disc with a few central larger (generally oblong) cellules, stellately arranged, and forming an umbilical rosette (rim striated).*

† Disc large, and its cellules distinct.

COSCINODISCUS *centralis* (E.). — Cellules minute, nearly equal, in crowded radiating series; umbilical rosette of a few oblong cellules round a circular one. EM. pl. 18. f. 39; GDC. p. 28, pl. 3. f. 50. Fossil. Virginia and Sicily. A large species with striated rim.

C. *omphalanthus* (E.). — Cellules in radiating series, marginal ones smaller, 7 to 8 in 1-1200″, middle ones larger, 6 in 1-1200″; umbilical rosette of 7 or 8 large oblong cellules. KSA. p. 125. Bermuda deposit. Disc large. D. 1-96″. Mr. Brightwell finds it difficult to distinguish this species from the following, and considers their specific characters unsatisfactory.

C. *Oculus Iridis* (E.). — Cellules hexagonal, in radiating series, smaller at the margin and near the umbilical rosette, which is formed of from 5 to 9 large oblong cellules. EM. pl. 18. f. 42. Fossil and recent. America, Europe, Milford Haven, &c. This large species, when dry, is marked with coloured rings,—an effect apparently due to the peculiar arrangement of its cellules. It differs from *C. centralis* in its larger cellules, and from *C. asteromphalus* by the absence of a veil. "This species, both in the recent and fossil specimens, often acquires a size not much inferior to that of *C. gigas*" (Bailey).

"*C. borealis* (Bail.). — Disc having at its depressed centre a conspicuous star, formed of about 6 large cellules. The rest of the surface covered with interruptedly radiant lines of prominent hexagonal cellules, which increase regularly from near the centre to the convex margin." B. in Amer. Journ. of Science and Arts, 1856. Sea of Kamschatka. "This resembles *C. Oculus Iridis*; but the cellules forming the star are more rounded, and the other cellules are larger" (Bailey).

C. *asteromphalus* (E.). — Cellules in radiating series, smaller towards the margin; umbilical rosette distinct; surface appearing as if covered by a very finely punctated veil. EM. pl. 18. f. 45. Fossil. America. Cellules large, rather tumid. *C. asteromphalus* differs from the other species with stellate umbilicus by its minutely punctated cellules.

2† Disc with cellules obscure, and requiring the higher magnifying powers to discern them.

C. *concinnus* (Sm.).—Disc large, with radiating series of minute puncta, and an umbilical irregular rosette of larger cellules, divided into compartments by radiating lines, which terminate at the margin in minute spines. (v. 89.) SBD. ii. p. 85; Roper, MJ. vi. p. 20, pl. 3. f. 12. Europe. Valves convex. In some specimens the markings are very inconspicuous, and difficult to detect; in others, as in the specimens from Hull, more evident.

C. *stellaris* (Roper). — Disc extremely hyaline, with very fine, inconspicuous radiating series of puncta, and a few larger, stellately arranged umbilical cellules. (v. 83.) Ro MJ. vi. p. 21, pl. 3. f. 3. Caldy, Pembrokeshire. When mounted in balsam, the disc is so hyaline, and the puncta so difficult to detect, that it is liable to be regarded as a detached ring. Dry valves brownish, without marginal spines.

2* *Disc with a central hyaline umbilicus, which often resembles a perforation. (The species are commonly smaller than those of the preceding section.)*

C. *actinochilus* (E.).—Granules in close lines, radiating from the distinct punctated umbilicus, separated from the margin by a border of puncta arranged in close, short, radiating lines. EM. pl. 35 A. 21. f. 5. Antarctic Sea. The radiating series of granules are close, but distinct.

C. *Lunæ* (E.). — Granules equal, arranged in distinct series, radiating from the smooth umbilicus, and separated from the margin by a border of minute puncta. EM. pl. 35 A. 21. f. 7. Antarctic Sea. Somewhat resembles *C. actinochilus*, but has fewer rays, the marginal puncta are more obscure, and the umbilicus is smooth.

C. *gemmifer* (E.). — Disk with conspicuous granules, arranged in lax and elegantly radiating lines from a smooth umbilicus; border minutely punctated. EM. pl. 35 A. 22. f. 3. Antarctic Sea. Bermuda deposit. The rays are fewer and more distant than in the two preceding species; but all agree in having well-marked granules, distinct rays, and minute submarginal puncta. Diam. 1-456″. Very like *Pyxidicula gemmifera*, but larger and more depressed.

C. *apiculatus* (E.). — Cellules rather prominent, apiculate, rendering the surface rough, subequal, radiating, 10 in 1-1200″; umbilicus smooth. EM. pl. 18. f. 43. America. Diam. 1-324″. Has a general resemblance to *Pyxidicula gemmifera*.

C. *perforatus* (E.). — Cellules minute, arranged in close, radiating series; umbilicus smooth, resembling a perforation; margin finely rayed. EM. pl. 18. f. 46. America. Diam. 1-348″. Differs from *C. fimbriatus* by its umbilicus.

C. *disciger* (E.).—Differs from *C. perforatus* by its irregularly circular, not smooth, and larger umbilicus, and by its very minute and dense punctiform cellules.* KSA. p. 123. Virginia. Diam. 1-480″. Cellules about 30 in 1-1200″.

C. *Apollinis* (E.).—Disc with numerous series of very dense, equal, punctiform granules, radiating from a small umbilicus. EM. pl. 35 A. 22. f. 4. Antarctic Sea. It differs from *C. Lunæ* by the greater number and denseness of its rays, which, however, although numerous, are distinct. Diam. 1-432″. 17 granules in 1-1200″.

C. *cingulatus* (E.). — Disc with very dense, punctiform granules, indistinctly radiating from a small clear umbilicus; margin with an annular band capable of being detached. EM. pl. 35 A. 21. f. 6. Fossil. America, Antarctic Sea. 26 granules in 1-1200″. Diam. 1-552″. Resembles *C. Apollinis*, but its granules are denser and less distinctly radiating.

3* *No umbilical vacancy; disc with a striated border distinct from the rim.*

C. *fimbriatus* (E.). — Cellules small, subequal, obsoletely radiating, near the margin smaller and arranged in radiating lines resembling striæ. E. *l. c.* pl. 22. f. 2. Fossil. Sicily.

C. *marginatus* (E.).—Cellules in curved lines; marginal ones smaller and arranged in radiating lines resembling striæ. E. *l. c.* pl. 18. f. 44. Recent and fossil. America, Cuxhaven. Cellules 9 or 10 in 1-1200″.

C. *limbatus* (E.). — Central cellules largest, not radiating, outer ones smallest, crowded, arranged in radiating lines resembling striæ. E. *l. c.* pl. 20. I. f. 29. Fossil, Greece. Diam. 1-576″. The largest 7 in 1-1200″.

C. *striatus* (K.). — Cellules irregularly crowded in the middle; margin of disc with radiating striæ. KB. t. 1. f. 8. Cuxhaven. Diam. 1-456″.

4* *Disc with radiating series of cellules; no distinct umbilicus, nor striated border distinct from the rim.*

C. *gigas* (E.).—Disc very large; cellules large, hexagonal, radiating, largest at the margin, decreasing towards the centre. EM. pl. 18. f. 34. Virginia; Maryland; alive, Cuxhaven. The largest species of the genus, and well characterized by its large hexagonal cellules gradually decreasing in size from the margin to the centre. Rim striated.

C. *excavatus* (Grev. MS.).—Disk large, with hexagonal cellules decreasing in size towards the centre, which has three conspicuous depressions alternating with the same number of elevations. Piscataway deposit. The disc in this species is, from its large size, visible to the naked eye, and, like *C. gigas*, it appears ring-like, the smaller central cells being then invisible. There is no distinct umbilicus; but the central portion, including the elevations and depressions, is thinner and is rarely found perfect. The cellules of the depressions appear smaller and more radiant than the others. (VIII. 26.)

C. *crassus* (Bail.). — Disc without a central star, covered with interruptedly radiant lines of large, prominent, hexagonal cellules with circular pores; cellules somewhat larger near the margin. B. Amer. Journ. Science, 1856. Alive, Sea of Kamtschatka; fossil, Monterey.

C. *profundus* (E.). — Cellules of disc subequal, near the margin smaller and irregularly radiating. ERBA. 1854; EM. pl. 35 B. f. 8. Atlantic.

C. *radiatus* (E.). — Cellules rather large, arranged in radiating lines (EM. pl. 21. f. 1; SBD. pl. 3. f. 37), smaller near the margin. (XI. 39, 40.) Common, both recent and fossil. Diam. 1-860" to 1-240". The radiating arrangement is sometimes obscure.

C. *Sol* (Wallich).—Disc as in *C. radiatus*, but surrounded by a broad, hyaline, membranous border, which is divided into compartments by numerous radiating lines. Wallich, TMS. viii. pl. 2. f. 1, 2. From Salpæ, Bay of Bengal, and Indian Ocean. On subjecting the frustule to acids, the membranous ring is at first simply detached, and after a while dissolved (Wallich).

C. *Argus* (E.).—Cellules large, somewhat smaller at the centre and margin; the radiating arrangement often interrupted. EM. pl. 21. f. 2. Recent, Cuxhaven; fossil, Oran and Sicily. May be a variety of *C. radiatus*, from which, however, Mr. Brightwell considers it sufficiently distinct. He finds the cellules in that species always radiant, whilst in the present they have no definite arrangement.

C. *radiolatus* (E.).—Granules punctiform, equal, radiating. E. *l. c.* pl. 18. f. 36. Fossil, Virginia. Differs from *C. Apollinis* by the absence of an umbilicus. 18 cellules in 1-1200".

C. *subtilis* (E.).—Granules punctiform, small, equal, radiating. E. *l. c.* pl. 18. f. 35. America. Similar to *C. radiolatus*, but with 24 cellules in 1-1200".

C. *Normanni* (Greg.).—Disc with radiating series of faint areolæ arranged in fasciculi of about 6 rows each; areolæ equal, except near the margin, where they are smaller; rim smooth. Grev MJ. vii. p. 81, pl. 6. f. 3. In stomach of Ascidians. Hull. Areolæ about 24 in ·001". No distinct umbilicus. Differs from *C. subtilis* by having only half as many lines in each fasciculus (Grev.).

C. *punctatus* (E.). — Cellules punctiform, radiating, loosely disposed at the centre, very densely crowded at the margin, and forming a broad, yellowish-white border. EM. pl. 18. f. 41; KSA. p. 124. Virginia. Cellules at centre, 24 to 26 in 1-1200". Diam. 1-348". Ehrenberg gives a figure of an oval variety of this species, pl. 18. f. 40.

C. *tenellus* (E.).—Cellules very small, equal, radiating. EB. 1854. Atlantic. 17 or 18 cellules in 1-1200". The characters given are insufficient to distinguish this species from *C. radiolatus* and *C. subtilis*.

C. *granulatus* (E.).—Disc small, with dense series of very small cellules, causing a granular appearance; granules 18 to 21 in 1-1152". KSA. p. 122. Fossil. Virginia. Diam. 1-552".

C. *umbonatus* (Greg.). — Disc densely cellulate, having a broad, nearly flat marginal zone, the central portion being nearly or quite hemispherical; cellules generally radiant, small and irregular in outline. Diam. ·0045". Lamlash Bay. GD. p. 28, pl. 2. f. 48.

5* *Cellules not radiating; no distinct umbilicus or striated border.*

† Cellules arranged in more or less perfect concentric circles.

C. *Patina* (E.). — Disc large, with moderate-sized cellules, disposed in concentric circles and becoming smaller towards the margin. KB. p. 1. f. 15. Fossil, Greece; alive, Cuxhaven. The young and vigorous specimens of live individuals are completely filled with yellow granules, whilst the older ones have an irregular yellow granular mass within them. Diam. 1-860" to 1-240".

C. *isoporus* (E.). — Disc coarsely cellular; cellules close, arranged in concentric circles. EM. pl. 33. 17. f. 3. Disc of moderate size. Ehrenberg's figure bears some resemblance to *C. concavus*, but has concentric cellules, and no distinct rim.

C. *velatus* (E.). — Cellules large, angular, rather distant, arranged somewhat concentrically; the disc punctated, appearing as if covered with a veil. E. *l. c.* pl. 18. f. 37. Virginia. Diam. 1-492".

2 † Cellules in parallel or curved lines.

C. *lineatus* (E.). — Cellules small, circular, arranged in straight, parallel lines. KB. pl. 1. f. 10. Fossil, Sicily and America; alive, Cuxhaven. Common. The cells in this species form parallel lines in whatever direction they may be viewed. In large and well-preserved fossil specimens as many as twenty-five openings (? spines) were seen near the circumference. Within the live forms sometimes numerous yellow vesicles are seen, as in Gallionella. Diameter of fossil 1-1150" to 1-480"; living, 1-1150" to 1-860".

C. *eccentricus* (E.). — Cellules small, disposed in excentric curved lines. KB. pl. 1. f. 9. Common, both recent and fossil. D. 1-860 to 1-430".

3† Cellules in no determinate arrangement.

C. *concavus* (E.). — Each valve very concave, the two opposite conjoined, forming an entire, very convex body; cellules coarse, equal, not radiating. EM. pl. 18. f. 38; GDC. pl. 2. f. 47. Virginia. Cellules 4 in 1-1200". An African variety has twice as many. = *Melosira cribrosa*, Sm ANH. xix. p. 11, pl. 2. f. 15.

C. *heteroporus* (E.). — Cellules hexagonal, smaller at the margin and centre, intermediate ones largest, unequal. KA. p. 123. Bermuda deposit. D. 1-360". This species may be recognized by the smaller marginal and central cellules and the very unequal intermediate ones.

C. *minutus* (Kütz.). — Disc nearly smooth, margin with punctated rays. D. 1-1416". KB. t. 1. f. 14. Cuxhaven.

C. *minor* (E.).—Margin smooth; disc irregularly and densely celluloso-punctate. Fossil, Sicily and Virginia; alive, Europe and America. E. *l. c.* Not *C. minor* of SBD.

C. *flavicans* (E.). — Disc small, with very fine non-radiating cellules, yellow by transmitted, but white by reflected light. KSA. p. 122. Peru and St. Domingo.

C. *labyrinthus* (Roper).—Disc divided by dotted lines into large, irregular, hexagonal, minutely dotted spaces; puncta 15 in ·001". Ro MJ. vi. p. 21, pl. 3. f. 2. Pembrokeshire. This species has somewhat the aspect, under a low power, of a finely marked specimen of *C. eccentricus*, but differs in the absence of a spinous margin, and in the large and irregularly shaped hexagonal spaces without any clearly defined margin (Ro.).

Doubtful or imperfectly known Species.

C. *cinctus* (K.). — Rim with interrupted radiating striæ; cellules of disc crowded in the centre, the others scattered, remote. KSA. p. 122. *C. Patina*, B. Amer. Jour. of Science and Arts, 1842, pl. 2. f. 13. Alive, Cuxhaven; fossil, Virginia. Diam. 1-324". Ehrenberg refers the Virginian specimens to *C. minor*.

C. *ovalis* (Ro.).—Valves oval, brownish in balsam, with finely-dotted radiating lines and no distinct umbilicus. Ro MJ. vi. p. 22, pl. 3. f. 4. Pembrokeshire. Markings very delicate and inconspicuous. (v. 78.)

C. *punctulatus* (Greg.).—Disc marked with very fine and obscure lines, the whole surface sparsely punctate. Lamlash Bay. GD. p. 28, pl. 2. f. 46.

C. *nitidus* (Greg.).—Disc marked with distant and irregularly radiant granules, larger towards the centre; margin striate, striæ about 16 in ·001". Lamlash Bay. Greg. *l. c.* p. 27, pl. 2. f. 45. (VIII. 18.)

C. *cervinus* (Bri.). — Disc minutely punctate, puncta scattered; centre convex. Diam. ·0054" to ·0085". = *Hyalodiscus cervinus*, Bri JMS. viii. p. 95, pl. 5. f. 9. Arctic regions.

Genus ENDICTYA (Ehr.).—Frustules disciform, simple or forming short filaments, closely cellulose, in front view with a middle furrow, having on each side crowded parallel series of cellules. Kützing places its only species in Coscinodiscus; but we think that it is much more nearly allied to Orthosira.

ENDICTYA *oceanica* (E.). — Disc with close cellules and a dentate rim. (v. 70.) EM. pl. 35 A. 18. f. 6, 7. = *Orthosira oceanica*, Bri JMS. viii. p. 96, pl. 6. f. 16. Common in Peruvian guano. Sometimes the cellules of the disc are almost concentric in their arrangement, 7 in 1-1152". Diam. 1-528". This form is probably identical with *Coscinodiscus concavus* and *Melosira cribrosa*.

Genus CRASPEDODISCUS (Ehr.). — Frustules simple, disciform; disc cellulose, without striæ or septa, but having a broad, well-defined, tumid border of a different structure from the centre. Craspedodiscus has the habit of Coscinodiscus, with which Kützing united it. It differs from *Coscinodiscus limbatus*, and similar forms, by its margin, which does not form a mere rim, but a broad border of a different structure, separated from the centre by a distinct furrow or well-defined line.

CRASPEDODISCUS *elegans* (E.).—Border with obliquely quadrate cellules; disc with a central rosette of five or six oblong ones, the others being circular and somewhat radiating. (XI. 38.) EM. pl. 33. 18. f. 2. = *Coscinodiscus elegans*, KSA. p. 126. Bermuda deposit. Frustules large, with an elegantly marked border, the diameter of which is much less than that of the centre. This species differs from the rest in its central rosette and diagonally marked border.

C. *Coscinodiscus* (E.).—Border broad, but of less diameter than the centre; cellules of border large, close; those of centre minute or puncta-like, and scattered. (V. 80.) EM. pl. 35. 16. f. 8. = *Pyxidicula Coscinodiscus*, EB. 1844; *Coscinodiscus Pyxidicula*, KSA. p. 126; Br JMS. viii. p. 95, pl. 5. f. 4. Fossil. United States.

C. *microdiscus* (E.). — Border very broad, its diameter greater than that of the centre; cellules of border large, close; those of centre minute, scattered. E. *l. c.* pl. 33. 17. f. 4. Fossil. United States. Resembles *C. Coscinodiscus*, from which it differs in its proportionally smaller centre.

Doubtful Species.

C.? *Stella*, EM. pl. 35 B. B. 4. f. 11. Ehrenberg's figure represents a smooth disc with a Melosira-like umbilicus, from which radiate irregularly placed lines.

C.? *Franklini*, EM. pl. 35 A. 23. f. 6. = *Hyalodiscus subtilis*.

C. *marginatus* (Bri.).—Disc with hyaline margin, having about 20 rays; remainder of the valve minutely punctate. Diam. ·0037″. Barbadoes deposit. Br JMS. viii. p. 95, pl. 5. f. 7.

C. *semiplanus* (Bri.). — Margin very broad, faintly radiate and punctate. One half of central part of the valve smooth, the remainder with 4 or 5 radii. Diam. ·0024″ to ·0035″. Barbadoes deposit. Br. *l. c.* p. 95, pl. 5. f. 12.

C. *coronatus* (Bri.). — Only fragments of this form have hitherto been found, and consequently no satisfactory specific character can be given. Br. *l. c.* p. 95. f. 6.

Genus ODONTODISCUS (Ehr.).—Frustules simple, orbicular; disc without nodule or septa, but with dotted rays and erect teeth. Odontodiscus differs from Coscinodiscus and Actinocyclus by having its disc furnished with teeth, of which the others are destitute. The dots are radiate, not parallel, as in Systephania.

ODONTODISCUS *Spica* (E.). — Teeth submarginal, numerous (48); granules in radiating series. KA. p. 129. Fossil. Virginia. Granules 19 in 1-1152″.

O. *Uranus* (E.).—Disc with numerous (32) radiating series of granules and marginal teeth. KSA. p. 129. Fossil. Virginia. *O. Uranus* has marginal teeth and fewer radiating series of granules than *O. Spica*; but we doubt whether they be really distinct species.

O. *eccentricus* (E.). — Disc with its granules arranged in eccentric, curved, indistinctly radiating rows; teeth numerous, marginal. (V. 90.) EM. pl 35 A. 18. f. 11. = *Coscinodiscus eccentricus*, SD. i. p. 23, pl. 3. f. 38.? Fossil. Guano, &c. Granules about 20 in 1-1152″. D. 1-864″. This species differs from Coscinodiscus only in having teeth, and may be merely that state of the latter which is described and figured by Professor Smith as spinous. We, however, have generally failed to detect the spines in the *Coscinodiscus eccentricus*, although they are obvious enough in the Odontodiscus, which is usually much smaller. On these accounts we cannot decide that they are identical.

Genus SYSTEPHANIA (Ehr.). — Frustules orbicular; disc cellulose, neither radiate nor septate, with an external circlet of spines or an erect membrane on the disc, not on the margin; cellules in parallel rows. "The genus has the habit of *Coscinodiscus lineatus*, but with lateral crowns, which, in the young state, unite two individuals" (Bailey). The spines are subulate, and appear not unlike the peristome of a moss.

SYSTEPHANIA *aculeata* (E.). — Disc loosely cellulose; cellules distinct, spines erect, not crowded, few (12 to 15), placed on the disc near the margin. KA. p. 126. Bermuda. Cellules 8 in 1-1152″. Diam. 1-324″. This species is distinguished by its fewer spines and more conspicuous cellules.

S. *Corona* (E.). — Disc densely cellulose; spines erect, numerous (40 to 50), closely set, placed on the margin. EM. pl. 33. 15. f. 22. Bermuda, Virginia.

Cellules 12 in 1-1152″. Diam. 1-348″. The spines are far more numerous and the cellules less distinct than in *S. aculeata*.

S. *Diadema* (E.).—Disc densely cellulose; spines numerous, marginal, incurved, conjoined at their extremities by a membrane. EM. pl. 33. 18. f. 11. Bermuda. Cellules 14 in 1-1152″. Diam. 1-864″. Much smaller than the two preceding species. All have a variable number of teeth.

Genus SYMBOLOPHORA (Ehr.). — Frustules orbicular, not concatenate; disc with striæ or dotted lines, radiating from a solid angular centre. Symbolophora differs from Actinocyclus in having an angular or stellate hyaline centre.

Ehrenberg has placed in this genus forms which agree only in their hyaline angular umbilicus; and the species with radiating series of dots scarcely differ from Coscinodiscus.

Symbolophora *Trinitatis* (E.).—Disc having a triangular crystalline umbilicus with a crenated margin, from which radiate six fascicles of very fine lines diverging towards the margin. EB. 1844, p. 88. (xi. 36.) Fossil. Maryland. We believe no one except Ehrenberg has observed this species, for which the genus was constituted; and it has been suggested that his figure may represent what he erroneously supposed to be the original form (as shown by a fragment) of *Triceratium Marylandica*; but in this opinion we cannot concur, because in several instances where Ehrenberg has founded species on mere fragments he has figured the fragments as he observed them, without attempting a restoration of their supposed entire figure.

S. *acutangula* (E.). — Resembles the preceding in size and habit, but has the angles of its umbilicus acute. EB. 1845, p. 81. Fossil. Virginia.

S.? *Microtrias* (E.). — Disc turgid, with a stellate umbilicus, from which radiate series of puncta. Antarctic Ocean. Umbilicus triradiate = *S. Microtrias*, E. *l. c.* 1844, p. 205; EM. pl. 35 a. 21. f. 16. Umbilicus cruciate or four-rayed = *S. Tetras*, E. *l. c.* Umbilicus five-rayed = *S. Pentas*, EM. pl. 35 a. 22. f. 19. Umbilicus six-rayed = *S. Hexas*, E. *l. c.* This species differs from a Coscinodiscus only in the presence of the stellate umbilicus.

Genus HETEROSTEPHANIA (Ehr.).—Characters unknown to us.

Heterostephania *Rothii*, EM. pl. 35 a. 13 b. f. 4, 5. (v. 85.) Elbe. Disc with radiating series of minute puncta, 8 or 10 marginal teeth or minute processes, and no umbilicus. Front view with minute, erect, marginal teeth.

Genus HALIONYX (Ehr.).— Frustules orbicular, not concatenate; disc rayed; number of rays definite, not starting from the umbilicus; no internal septa. It resembles Actinocyclus, except in its umbilicus not being radiate; or, in other words, its central ocellus is wanting. In like manner Coscinodiscus differs from Symbolophora in its non-radiate umbilicus, which is a simple void space.

Halionyx *senarius* (E.).—Surface of disc with six rays; each compartment is marked by parallel lines, which decrease by equal gradations on either side of a radiating median line; loosely and widely cellulose; umbilicus entire, punctated. KA. p. 130. Antarctic Ocean. Diam. 1-720″. Approaches *Actinoptychus undulatus*.

H. *undenarius* (E.).—Disc with eleven or twelve rays; umbilicus large, punctated, not radiant. (v. 82.) EM. pl 35 a. 21. f. 12. = *H. duodenarius*, E. olim. Antarctic Ocean. Diam. 1-576″. Ehrenberg's figure shows the disc with a granulated centre, from which proceed radiating series of puncta and eleven darker or shade-like rays.

Genus ACTINOCYCLUS (Ehr.).—Frustules simple, disciform; disc minutely and densely punctated or cellulose, generally divided by radiating single or double dotted lines, and having a small circular hyaline intramarginal pseudo-nodule. We consider Actinocyclus, as limited by Ehrenberg, a well-marked genus. Its confusion has arisen from Professor Kützing's retention in it of some species of Actinoptychus, and the application of its name by Professor Smith to the latter genus. The disc is not undulated; and the rays, which are often very indistinct, are dotted or interrupted, not continuous lines. From the minute size and close arrangement of the puncta, the frustules, when mounted in Canada balsam, never appear hyaline, but of a brownish or, more frequently, of a beautiful purplish colour. The disc is furnished with an intramarginal pseudo-nodule, which simulates an orifice. Ehrenberg in this, as in other genera of Diatomaceæ, distinguished his species solely by the number of their rays; but we cannot retain them, as we consider species founded on such characters altogether unscientific and erroneous. In general, names once bestowed ought to be retained, even when somewhat inappropriate or defective, because less injury is done by their retention than by burdening the science with synonyms; still we believe it far better to bestow a new name when, as in this genus, numerous species are reduced to one to which the original names would be inapplicable.

ACTINOCYCLUS *moniliformis* (n. sp.).—Disc divided into compartments by three or more rays, formed of single series of dots, in a moniliform arrangement. = *A. ternarius*, EM. pl. 22. f. 9. Fossil. Europe, Africa, and America. This species includes most of Ehrenberg's figures of Actinocycli from the deposits of Greece, Oran, Sicily, and Virginia (pls. 18, 19, 21 & 22). We have seen no specimens; but in Ehrenberg's figures the single moniliform rays differ so greatly from what we find in the following species that we must consider them distinct, although Ehrenberg, in consequence of his regarding the number of the rays as the essential character, has mixed up its forms with those of the following species under the same names.

A. *Ehrenbergii* (n. sp.). — Disc generally iridescent, closely punctated, so as under a low power to appear waved, divided by regular equidistant rays formed of interrupted double lines, which terminate at the margin in minute teeth. Common, both recent and fossil. Very fine in Ichaboe guano. Under this name we include all Ehrenberg's species with rays composed of double lines. The rim is narrow, but generally distinct; pseudonodule minute. In fluid, *A. Ehrenbergii* is colourless; but when mounted in balsam, it, like the next species, varies with different shades of brown, green, blue, purple, and red. The rays are formed by lines composed of linear or subulate hyaline spaces, which, more frequently than in *A. Ralfsii*, are in pairs, though sometimes alternate; they are often indistinct, especially in smaller specimens. This species is best recognized by the waved appearance of its puncta.

We subjoin a list of forms included in *A. Ehrenbergii*, but by Ehrenberg regarded as distinct species. Most of them may be obtained from Ichaboe guano. We unite them all in this species:— *A. ternarius*, 3 rays; *A. quaternarius*, 4; *A. quinarius*, 5; *A. biternarius*, 6; *A. septenarius*, 7; *A. octonarius*, 8; *A. nonarius*, 9; *A. denarius*, 10; *A. undenarius*, 11; *A. bisenarius*, 12; *A. tredenarius*, 13; *A. bisептenarius*, 14; *A. quindenarius*, 15; *A. bioctonarius*, 16; *A. septemdenarius*, 17; *A. binonarius*, 18; *A. novemdenarius*, 19; *A. vicenarius*, 20; *A. Luna*, 21; *A. Ceres*, 22; *A. Juno*, 23; *A. Jupiter*, 24; *A. Mars*, 25; *A. Mercurius*, 26; *A. Pallas*, 27; *A. Saturnus*, 28; *A. Terra*, 29; *A. Venus*, 30; *A. Vesta*, 31; *A. Uranus*, 32; *A. Acharneus*, 33; *A. Aldebaran*, 34; *A. Antares*, 35; *A. Aquila*, 36; *A. Arcturus*, 37; *A. Bet-el-gose*, 38; *A. Canopus*, 39; *A. Capella*, 40; *A. Fom-el-hot*, 41; *A. Lyra*, 42; *A. Procyon*, 43; *A. Regulus*, 44; *A. Rigl*, 45; *A. Sirius*, 46; *A. Sol*, 47; *A. Spica*, 48; *A. Stella polaris*, 49; *A. Ninus*, 50; *A. Alexander*, 51; *A. Ptolemæus*, 52; *A. Davides*, 53; *A. Numa*, 54; *A. Crœsus*, 55; *A. Dux*, 56; *A. Rex*, 57; *A. Imperator*, 58; *A. Plutus*, 59; *A. Proserpina*, 60; *A. abundans*, 61; *A. luxuriosus*, 62; *A. prodigus*, 63; *A. fortunatus*, 64; *A. locuples*, 65; *A. opiparus*, 66; *A. pretiosus*, 67; *A. polyactis*, 68; *A. magnificus*, 69; *A. Zoroaster*, 70; *A. Solon*, 71; *A. Cleobulus*, 72; *A. Chilo*, 73; *A. Pittacus*, 74; *A. Thales*, 75; *A. Bias*, 76; *A. Periander*, 77; *A. Socrates*, 78; *A. Salomon*, 79; *A. Homerus*, 80; *A. Hesiodus*, 81; *A. Tyrtæus*, 82; *A. Anacreon*, 83; *A. Sappho*, 84; *A. Pindarus*, 85; *A. Æschylus*, 86; *A. Sophocles*, 87; *A. Euripides*, 88: *A. Virgilius*, 89; *A. Horatius*, 90; *A. Tubelcain*, 91; *A.*

Dædalus, 92; *A. Callimachus*, 93; *A. Phidias*, 94; *A. Praxiteles*, 95; *A. Pyrgoteles*, 96; *A. Apelles*, 97; *A. Zeuxis*, 98; *A. Orpheus*, 99; *A. Apollo*, 100; *A. Adamas*, 101; *A. Achates*, 102; *A. Amethystus*, 103; *A. Astrolites*, 104; *A. Beryllus*, 105; *A. Carbunculus*, 106; *A. Chrysolithus*, 107; *A. Hyacinthus*, 108; *A. Iaspis*, 109; *A. Iasponyx*, 110; *A. Leucochrysus*, 111; *A. Omphus*, 112; *A. Onyx*, 113; *A. Opalus*, 114; *A. Saphirus*, 115; *A. Sarda*, 116; *A. Sardonyx*, 117; *A. Smaragdus*, 118; *A. Topazius*, 119; *A. Panhelios*, 120.

A. *Ralfsii* (Sm.). — Disc iridescent, with close radiating series of punctiform granules, interrupted by numerous subulate hyaline spaces, which are crowded in the centre and more distant near the margin, where they form irregular rays of double broken lines; marginal teeth and pseudo-nodule as in *A. Ehrenbergii*. = *Eupodiscus Ralfsii*, SBD. ii. p. 86. British coast. (v. 84.) *β. sparsus* (Greg. in lit.), granules in loose series, without angular blanks, the principal rays alone reaching the umbilicus, =*Eupodiscus sparsus*, Greg TMS. v. p. 81, pl. 1. f. 47: Scotland. "The lines of cellules diminish in number at distinct intervals from the margin towards the centre of the valve, giving a zoned appearance when seen under a low power" (SBD.). *A. Ralfsii* differs from *A. Ehrenbergii* in the radiated arrangement of its granules, the far greater number of hyaline spaces, and the more irregular distribution of the rays, in which also the blank spaces in the associated lines are usually alternate. The following remarks on the var. *sparsus* are condensed from Professor Gregory's papers: — Principal rays equidistant, formed of large dots not closely set; between the principal rays, the inner ends of which leave a small central umbilicus, occur shorter series parallel to each other, the middle one longest, the others progressively decreasing in length on each side, and the shortest adjacent to the principal rays, which they approach at an angle. Professor Gregory finds the same arrangement in *A. Ralfsii*; but in that form the dots are large and very close. In *A. Ralfsii* the colour varies with different shades of purple, blue, green, and yellow, and sometimes brown or buff. At Professor Gregory's suggestion, we reduce *A. sparsus* to the rank of a variety, as he finds the species to vary much in the size of the granules, in their closeness, and in colour.

A. *fulvus* (Sm.).—"Cellular structure indistinct, radiate; colour of dry valve tawny." = *Eupodiscus fulvus*, SBD. i. p. 24, pl. 4. f. 40. Britain. Rays obscure. We doubt whether this species be distinct from *A. Ehrenbergii*, many specimens of which have very indistinct rays.

A. *crassus* (Sm.). — Disc somewhat opaque, purplish when dry; granules in radiating series; pseudo-nodule as in *A. Ralfsii*; margin smooth. = *Eupodiscus crassus*, SBD. i. p. 24, pl. 4. f. 41. Britain. Mr. T. West believes this species to be an immature state of *A. Ralfsii*.

Doubtful Species.

A. *Panhelios* (E.).—Very large; disc with 120 very fine rays. KSA. p. 128. Cuxhaven. Diam. 1-180″.

* *Disc generally coloured, furnished with radiating series of puncta.*

A. *interpunctatus* (Bri.). — Disc with an indefinite number of double rays running from the centre to near the circumference; the rays composed of short, broken lines; the spaces between the rays are minutely punctate. California, New Zealand, West Indies. = *Actinoptychus interpunctatus*, Bri JMS. viii. p. 94, pl. 6. f. 17.

A. *subtilis* (Greg.).—Disc very hyaline, with numerous very fine inconspicuous radiating dotted lines, a circular punctated umbilicus, and rather distant marginal teeth. =*Eupodiscus subtilis*, GDC. p. 29, pl. 3. f. 50. Forming brown patches on sides of rocks. Ilfracombe, Plymouth. This species is easily distinguished by its hyaline appearance in balsam. The pseudo-nodule is minute, radiating lines indistinct, and the umbilicus is furnished with scattered dots surrounded by a dotted circle. Frustules sometimes contained in an indefinite mucous stratum.

2 * *Disk with hexagonal cellules, which are not in radiating lines.*

A. *tessellatus* (Ro.). — Cellules of disc distinct, hexagonal, with a minute nodule at each angle, not radiant. =*Eupodiscus tessellatus*, Ro JMS. vi. p. 19, pl. 3. f. 1. Pembrokeshire, Hull, Norfolk. Guano. This species is placed in Actinocyclus because of its solitary intramarginal pseudo-nodule; but in its structure it differs so much from the other species of that genus, that it might be separated from it. The reticulated disc and absence of rays distinguish it. In balsam it is nearly colourless.

Genus ASTEROLAMPRA (Ehr.).—**Frustules simple, disciform; disc orbicular, with marginal areolated or punctated compartments, separated by smooth rays which proceed from a hyaline central area; central area divided by lines, which radiate from the umbilicus to the apex of each compartment; compartments and rays symmetrical.** Marine. The disc in this beautiful genus is generally colourless, and when mounted in balsam is far from conspicuous, notwithstanding its comparatively large size. The marginal compartments are usually conical, and from the apex of each a line or rib proceeds to the umbilicus. The hyaline central area seems to originate from the dilated inner ends of the rays, and its lines to be produced by their junction. Asterolampra is distinguished from Asteromphalus by the compartments being similar and equidistant; on which account the rays are equal, the lines all radiant, and the umbilicus central.

* *Umbilical lines straight.*

ASTEROLAMPRA *Marylandica* (E.).—Umbilical lines simple, straight; areolated compartments conical or semicircular. EB. 1844, p. 76, f. 10; Wallich, TM. viii. p. 47, pl. 2. f. 13, 14; Grev TM. viii. p. 108, pl. 3. f. 1–4. = *A. septenaria*, Johns. Sill. Journ. 2nd ser. xiii. p. 33; *A. impar*, Sh TM. ii. pl. 1. f. 14; *A. pelagica*, EB. 1854, p. 238. Fossil, Virginia: Monterey stone, guano. Recent, India, &c. (XI. 33.) Rays 6 to 14. The disc varies greatly, not only in the number of rays, but in the elongated or depressed form of the compartments, producing a corresponding variation in the size of the central area.

A. *Rotula* (Grev.).—Resembles *A. Marylandica*, but the areolated compartments have subtruncate apices; umbilical lines straight. Grev TM. viii. p. 111, pl. 3. f. 5. Monterey stone. Umbilical lines simple or dividing in a forked manner, close to the central point.

A. *variabilis* (Grev.).—Compartments with cuneate apices; umbilical lines straight, mostly united in twos or threes near the central point. Grev TM. viii. p. 111, pl. 3. f. 6–8. Monterey stone. Rays 6 to 11.

A. *Grevillii* (Wallich, Grev.).—Compartments conical, with truncated apices; umbilical lines straight, variously united. = *Asteromphalus Grevillii*, Wall TM. viii. p. 47, pl. 2. f. 15; *Asterolampra Grevillii*, Grev TM. viii. p. 113, pl. 4. f. 21. Fossil, Virginia and Monterey stone; recent, Indian Ocean. This species approaches Asteromphalus in the appearance of the central area, but its marginal compartments and alternating rays are symmetrical. Rays numerous, 13 to 17.

2* *Umbilical lines angularly bent.*

A. *Brebissoniana* (Grev.).—Areolated compartments truncated; umbilical lines with an angular bend in the middle. Grev TM. viii. p. 114, pl. 3. f. 9. Monterey stone. Umbilical lines simple or united, close to the central point.

Genus ASTEROMPHALUS (Ehr.).—**Frustules simple, disciform; disc as in Asterolampra, but with two of the punctated compartments approximate, and the interposed ray narrower than the others.** Marine. Asteromphalus differs from Asterolampra in having two compartments closer together. The lines connecting these with the umbilicus do not radiate like the rest; and the enclosed hyaline ray consequently differs in form from the others, and is termed the median or basal ray.

* *Umbilical lines radiating from a central point, two of them approximated.* Asteromphalus.

† Umbilical lines straight or curved.

ASTEROMPHALUS *Hookerii* (E.).—Punctated compartments, conical or rounded at the apex; umbilical lines straight, the median ones parallel. EB. 1844, p. 200; EM. pl. 35 A. 21. f. 2. = *A. Buchii*, EB. 1844, p. 200; *A. Humboldtii*, E. *l. c.* p. 200; EM. pl. 35 A. 21. f. 3; *A. Cuvierii*, EB. 1844, p. 200; EM. pl. 35 A. 21. f. 1. Antarctic Ocean. (X. 34.) Rays 6 to 9. We consider that forms differing only in the number of their rays are not really distinct, and have consequently united Ehrenberg's species quoted above.

A. *Dallasianus* (Grev.).—Areolated compartments, with truncate apices; median lines campanulate. = *Asterolampra*

Dallasiana, Grev TM. viii. p. 115, pl. 4. f. 10. Bermuda, Tripoli.

A. *Wallichianus* (Grev.). — Areolated compartments, with truncate apices; umbilical lines straight. = *Asterolampra Wallichiana*, Grev TM. viii. p. 115, pl. 4. f. 11. Bermuda, Tripoli. "The umbilical portion of each ray is so wide next the areolated segments, that it may be compared to a short-bladed trowel, while the linear part represents the handle" (Grev.). According to Dr. Greville's figure, this species differs from Asterolampra only by its median ray being narrower than the rest.

2 † Umbilical lines with an angular bend.

A. *Beaumontii* (E.). — Compartments with rounded apices; umbilical lines with an angular bend; median ones straight, parallel. EB. 1844, p. 200, f. 5; Grev TM. viii. p. 115. Antarctic Ocean.

A. *Darwinii* (E.). — Compartments with rounded or subtruncate apices; umbilical lines with an angular bend; median ones bent or curved. ERBA. 1844, p. 200, f. 1. = *Asterolampra Darwinii*, Grev TM. viii. p. 116, pl. 4. f. 12, 13; *Asteromphalus Rossii*, ERBA. p. 200, f. 2; EM. pl. 35 A. 21. f. 4. Antarctic Ocean, Monterey stone. (v. 86.)

2 * *Disc subcircular, rays unequal; umbilical lines radiating from the top and sides of the median ones, which latter pass beyond and enclose the central point.* Spatangidium.

† Umbilical lines not bent.

A. *flabellatus* (Bréb., Grev.). — Punctated compartments, conic; umbilical lines straight or slightly curved, radiating from apex and sides of the median ones. Grev MJ. vii. p. 160, pl. 7. f. 4, 5. = *Spatangidium flabellatum*, Bréb. Bull. Soc. Linn. de Normand. iii. pl. 3. f. 3; *Asterolampra flabellata*, Grev TM. viii. p. 116; *Spatangidium peltatum*, Bréb. *l. c.* pl. 3. f. 4. Peruvian and Californian guanos. Rays 10 or 11; median one clavate; areolation of compartments very minute.

A. *Hiltonianus* (Grev.). — Punctated compartments narrowly conic; umbilical lines radiating from apex and sides of median lines, the two lower pair suddenly deflexed. = *Asterolampra Hiltoniana*, Grev TM. viii. p. 117, pl. 4. f. 15. Algoa Bay guano, Indian Ocean. Rays 10 to 19, slender; umbilical lines simple or forked; areolation very minute. It is a very transparent species, and easily overlooked, Grev.

A. *Arachne* (Bréb.). — Disc broadly ovate; hyaline area small and excentrical; areolated compartments, very unequal; umbilical lines straight, short; dilated head of median ray truncate. = *Spatangidium Arachne*, Bréb. Bull. Soc. Linn. de Normand. iii. pl. 3. f. 1; *Asterolampra Arachne*, Grev TM. viii. p. 123; *Asteromphalus malleus*, Wall TM. viii. p. 47, pl. 2. f. 11; *Excentron cancroides*, Ralfs in lit. (v. 66.) Peruvian guano, Indian Ocean. Distinguished by its malleiform median ray. Compartments with large areolation; umbilical lines less conspicuous than in the other species. Rays usually 5, sometimes 7; median and adjacent ones straight, the anterior pair curved. When there are only five rays, this species differs greatly in appearance from the rest by having the anterior margin of the head of the median ray in direct contact with the anterior compartment; but when the rays are 7 in number, the hyaline dilated portions of the anterior pair interpose between these parts, as in the other species.

2 † Umbilical lines with an angular bend.

A. elegans (Grev.). — Punctated compartments, conic, more than half the radius; umbilical lines with an angular bend, radiating from apex and sides of the median ones, usually simple, but sometimes two or three united. Grev MJ. vii. p. 7, pl. 7. f. 6. = *Asterolampra elegans*, MJ. viii. p. 118, pl. 4. f. 16. Californian guano, Indian Ocean. (v. 87.) Areolation extremely minute; rays 13 to 29, gracefully slender.

A. *imbricatus* (Wall.). — Areolated compartments, conic, less than half the radius; rays numerous, robust; angular bends of umbilical lines forming unitedly an oblong-elliptical figure. Wall TM. viii. p. 46, pl. 2. f. 9. = *Asterolampra imbricata*, Grev MJ. viii. p. 119, pl. 4. f. 17. Indian Ocean, Natal. Areolation considerably larger than in *A. elegans*, its nearest ally, Grev.

A. *Brookei* (Bail.).—Disc almost circular; areolation conspicuous; compartments truncated; angular bend of umbilical lines near the outer end; umbilical portion of median ray constricted beneath the rounded inner end, then dilated. Bail. Sill. Journ. 2 ser. xxii. p. 2, pl. 1. f. 1. = *Asterolampra Brookei*, Grev MJ. viii. p. 119, pl. 4. f. 18. Soundings, Kamtschatka, Atlantic. (v. 79.) The umbilical lines radiate from the upper half of the median ones, and are sometimes divided. The angular bend is nearer the outer end than in any other species; and at each angle is a minute spine-like process, Grev.

A. *Roperianus* (Grev.).—Disc circular, with its hyaline area centrical; areolated compartments, truncate, almost equal; umbilical lines radiant from rounded end of median ones; median lines passing round the central point in a semicircle, then contracted, and lastly widely expanded. = *Asterolampra Roperiana*, Grev MJ. viii. p. 120, pl. 4. f. 14. Indian Ocean. Rays 7, robust; areolation rather large, Grev.

A. *Shadboltianus* (Grev.).—Areolated compartments, truncate; umbilical lines radiant from the pyriform median ones, with the bend about the middle; rays not reaching the margin. = *Asterolampra Shadboltiana*, Grev MJ. viii. p. 121, pl. 4. f. 19. Indian Ocean. "Rays 7, robust; areolation rather large. Its nearest ally is perhaps *A. Brookei*, from which it is separated by the very different median lines and by the angular bend being more in their middle" (Grev.). Dr. Greville suspects that in this species, as in *A. Roperianus*, *A. heptactis*, and *A. Arachne*, the number of rays may be more constant than is generally the case in the group.

A. *heptactis* (Bréb.).—Areolated compartments, truncate; rays broad, linear, terminating in a lunate marginal fold, and bordered by a row of larger areolæ. = *Spatangidium heptactis*, Bréb. Bull. Soc. Linn. de Normand. iii. p. 3. f. 2; *Asterolampra heptactis*, Grev TM. viii. p. 122; *Spatangidium Ralfsianum*, TM. vii. p. 161, pl. 7. f. 7, 8. Peruvian and Californian guanos, Atlantic soundings. Rays 7, straight or slightly curved, the median one in a broad shallow groove, the linear portion faintly prolonged through the dilated portion to spurs from the bends of the adjacent umbilical lines. Areolation of compartments, conspicuous; disc subcircular. (VIII. 21.)

Doubtful or imperfectly described Species.

A. *centraster* (Johnston).—Disc orbicular; areolated compartments with rounded apices and bordered by a series of larger areolæ; umbilical lines straight, radiating from top and sides of median ones; rays terminating at the margin in nodules. Johnston, MJ. viii. p. 12, pl. 1. f. 10. Elide guano. (VIII. 14.) Rays 11. Dr. Johnston's figure differs from every known species by having the rays continued, as Dr. Greville remarks, like distinct bars or the ribs of an umbrella, from the central point to the margin. We believe, however, that this structure is similar to what is met with in several other species of Asterolampra and Asteromphalus (see especially Greville's figures of *Asterolampra variabilis*, *A. Wallichiana*, *A. Roperiana*, and *A. heptactis*), but more strongly marked, and probably exaggerated in the figure.

A. *stellatus* (Grev.). = *Asterolampra stellata*, Grev TM. viii. p. 124, pl. 4. f. 20. Indian Ocean. It is allied to *A. Hiltonianus* and *A. flabellatus*. The lowest pair of umbilical lines are curved downwards, as in the former species. The median lines are parallel. The valve, at a first glance, is most conspicuous for the large size of the hyaline area and the rapidly attenuated rays; but this may prove to be a worthless distinction.

A. *Sarcophagus* (Wall.).—Valve oblong, with inflated middle; median ray plane and continuous with the anterior ray; umbilical lines straight; areolation very large. Wallich, TM. viii. p. 47, pl. 2. f. 12. = *Asterolampra Sarcophagus*, Grev TM. viii. p. 124. Indian Ocean. "The broadest portion of this species is always towards the extremity opposite to the median ray, thus giving the valve a somewhat pyriform or sarcophagus-like shape" (Wallich). "The form of the valve is so extreme a deviation from the otherwise more or less orbicular shape of the entire series, that an impression almost forces itself upon the mind that it is simply a malformation. It is most nearly related to *A. Arachne*; for if we remove the terminal ray (which in many species may be either absent or present), the five remaining rays would occupy the relative position which they hold in that species, as well as in the same direction, one pair pointing upwards, the other pair downwards. In both species the areolation is large" (Grev.).

Genus ASTERODISCUS (Johnson).—Frustules simple, disciform; disc divided into punctated compartments, which do not reach the centre, by hyaline smooth rays; compartments connected to the umbilicus by an equal number of radiating lines, two united half way, the rest distinct. Fossil. (Johnson, in Silliman's Amer. Journ. 1852.) "The proximate genera, Asterolampra and Asteromphalus, are readily distinguished. In the former, all the connecting lines are symmetrical; in the latter, two are parallel;" whilst in this genus one line divides half-way from the centre and proceeds to two of the compartments, the smooth ray between which is smaller than the others, but not parallel as in Asteromphalus.

ASTERODISCUS *Johnsonii*. — Rays and umbilical divisions from five to nine. Bermuda earth. This includes the following species of Johnson:—

A. *quinarius*.—Marginal rays and umbilical divisions five.

A. *senarius*.—Marginal rays and umbilical divisions six.

A. *nonarius*.—Marginal rays and umbilical divisions nine.

"Front view bi-convex; compartments elegantly marked with minute dots, arranged in excentric curves" (Johnson).

Genus ACTINOPTYCHUS (Ehr.).—Frustules disciform, cellulose; disc divided into equal triangular compartments by lines or internal septa (E.). =Actinocyclus, Smith, not Ehr. The circular disc is cellulose, and divided into triangular portions by lines ("internal septa," E.) radiating from its centre. The alternate portions are usually more distinct, owing to the undulated form of the frustules, which causes them alternately to be nearer to or more remote from the eye. The apparent septa distinguish it from Actinocyclus, and the absence of spines from Heliopelta and Omphalopelta. We have not the slightest doubt that Ehrenberg has properly separated Actinocyclus from Actinoptychus. Professor Smith himself practically admits this, by placing the groups in different genera, although he has not retained the names as affixed by their author. If, however, the validity of their separation be admitted, the founder of these genera has surely an undoubted right to retain the original name for whichever group he thinks fit. Professor Smith seems to have erred by choosing as the type of Actinocyclus, not one of Ehrenberg's species, but a form placed in that genus by Professor Kützing, though really belonging to Actinoptychus.

ACTINOPTYCHUS *ternarius* (E.). — Disc with 3 or 5 radiating lines, without a distinct umbilicus; compartments even. KB. pl. 1. f. 19. = *A. quinarius*, E. Fossil. Virginia. The rays proceed directly to its centre, without leaving an umbilical space.

A. *undulatus* (Kütz.). — Disc with its compartments alternately prominent and cellulose and depressed and punctate; umbilicus indistinct or indefinite. = *Actinocyclus undulatus*, KB. pl. 1. f. 24; *Actinoptychus biternarius*, EM. pl. 18. f. 20; *A. biternatus*, EM. pl. 35 A. 16. f. 1. (v. 88.) America. Guano, &c. Compartments six or more.

A. *velatus* (E.). — Compartments six, loosely cellulose; surface apparently covered by a thin punctated membrane. KSA. p. 130. Virginia. We are unacquainted with this species, but think it may probably be a state of *A. undulatus*, the valves of which frequently consist of two dissimilar plates, one having the usual character, the other being triradiate and minutely punctate, and which has been described as a new species by Mr. Roper in TM. vi. p. 23 (*Actinocyclus triradiatus*), who first observed it detached from the true valve. He and others have since found the plates *in situ*.

A. *senarius* (E.). — Compartments (6 or more) alternately prominent, all loosely cellulose; umbilicus angular, definite; rim striated. EM. various plates. = *Actinocyclus undulatus*, SB. i. pl. 5. f. 43. (IX. 132.) Common, both recent and fossil. Mr. Tuffen West regards *A. senarius* and *Omphalopelta areolata* as identical. The presence of marginal spines in the latter seems indeed the only essential distinction; and we have generally succeeded in detecting spines, more or less distinct, exactly such as Professor Smith has represented in one of the figures of his *Actinocyclus undulatus*. The determination of species in Actinoptychus is very difficult. The number of the compartments, generally relied upon, we consider unessential, and we would separate into two species all those forms in which the compartments, irrespective of their number, are distinctly cellulose without any particular arrangement of their cellules. *A. undulatus* would thus include all those having a vague or indefinite umbilicus, and *A. senarius* those in which the umbilicus is separated from the cellulose compartments by a well-defined margin.

A. *splendens* (Shadbolt). — Compartments (12 to 20) obscurely cellulose, each with a median line, which terminates in a clavate intramarginal nodule or tooth; umbilicus hyaline, definite. = *Actinophænia splendens*, Sh TM. ii. p. 16; *Actinoptychus sedenarius*, E., Ro TM. ii. p. 74, pl. 6. f. 2. Common. Guano, England. In this species the alternate depressions of the compartments are often very slight; and the compartments being striated, frequently appear irregular, and are counted with difficulty. The species nevertheless has so peculiar an aspect, that, once known, it is easily recognized. The rays are most distinct where they radiate from the hyaline umbilicus, at which part they sometimes appear thickened. In some specimens the nodules are confined to the alternate compartments.

A. *elegans* (n. sp.).—Disk divided into compartments by lines radiating from a stellate, hyaline umbilicus; compartments punctated, and each bisected by a moniliform row of granules. =*A. octodenarius*, EM. pl. 21. f. 21. Oran. Ehrenberg has figured more than one form as his *A. octodenarius*; the compartments in his figure of this species are 9, and each is bisected by a moniliform ray.

A. *trilingulatus* (Bri.).—Valves divided by 6 alternately elevated segments. The elevated portions gradually rise from the circumference to near the centre, where they are rounded off; each alternate one has a submarginal row of dots or truncated processes. Surface delicately punctato-striate. ·0035" to ·0073". West Indies. Bri MJ. viii. p. 93, pl. 5. f. 2.

A. *spinosus* (Bri.).—Valves with 6 segments, alternately slightly elevated; margin occasionally spinous; each segment with 1 or 2 processes; umbilicus smooth, surface of the valve punctate. Monterey earth (or deposit). Bri MJ. viii. p. 94, pl. 6. f. 15.

A. *dives* (E.). — Disc divided into numerous (about 50) narrow compartments by lines radiating from a large, indefinite, punctated umbilicus, each compartment having a single series of granules. EM. pl. 19. f. 12. =*Discoplea dives*, E.; *Cyclotella dives*, KA. p. 20. Fossil. Ægina.

Doubtful Species.

A. *quaternarius* (E.). — Disc divided into 4 compartments by as many radiating lines. KA. p. 130. Virginia. Diam. 1-552". A state of *A. ternarius*?

A.? *hexapterus* (E.). — Disc with 6, thick, solid and conical rays; margin thick, undulated, denticulate internally. KA. p. 131. Fossil. Vera Cruz. (XI. 31.) A very doubtful Diatom.

A. *octonarius* (E.).—Disc divided into 8 compartments by as many radiating lines. Guano, &c. A state of *A. senarius*.

A. *denarius* (E.).—Disc with 10 compartments and 10 radiating lines. EM. pl. 18. f. 23. Cuxhaven and Virginia. We believe this species is founded on certain forms of *A. senarius* and *A. splendens*.

A. *duodenarius* (E.).—Disc divided by radiating lines into 12 compartments, which are alternately darker; in the centre of each compartment runs a narrow line, terminating at the margin in a minute pseudo-nodule, so that as many as 24 rays may be counted. Recent and Fossil. Europe, America. KA. p. 131. = *Heliopelta Phaethon*, MJ. viii. p. 13? A state of *A. splendens*?

The following species of Ehrenberg are distinguished by the number of rays only:—

A. *quatuordenarius*, 14 rays=*A. splendens*; *A. vicenarius*, 20 rays; *A. Ceres*, 22 rays; *A. Jupiter*, 24 rays (XI. 28). The three last are probably states of *A. splendens*.

Genus HELIOPELTA (Ehr.).— Frustules disciform, undulated disc cellulose, with external rays and internal septa, a striated margin, many erect submarginal teeth, and an angular centre. As in Actinoptychus, the frustule is undulated, and the disc divided into cuneate compartments or rays, which appear alternately more distinct; "but, in addition, they have near the margin a row of lateral spines, somewhat like the processes of Eupodiscus, but far more numerous, which probably connect the frustules together in the young state. Ehrenberg has dedicated the different species of this genus to persons distinguished in the history of microscopic research" (Bailey). As the species differ only in the number of compartments, they are probably not truly distinct.

HELIOPELTA *Metii* (E.).—Disc having loosely cellulose, elevated, radiating compartments, alternating with depressed ones marked with fine decussating lines; border a rather broad striated rim. Bermuda deposit. (XI. 35.) Compartments 6; umbilicus stellate. Diam. 1-372". Has the habit of *Actinoptychus velatus*. = *H. Metii*, EB. 1844, p. 268. Compartments 8; umbilical star tetragonal. Diam. 1-204".

H. *Leeuwenhoekii* (EM. pl. 33. 18. f. 5.). —Compartments 10; umbilical star pentagonal. Diam. 1-156".

H. *Euleri* (EM. pl. 33. 18. f. 6.). — Compartments 12; umbilical star hexagonal. Diam. 1-156".

H. *Selliquerii* (EB. 1844, p. 268.). — There are usually 3 teeth opposite each elevated compartment, and 2 opposite each depressed one; but sometimes, especially in the larger specimens, the teeth are more numerous, whilst in the smaller ones they are occasionally 1 less in each compartment.

Genus OMPHALOPELTA (Ehr.).—Frustules simple, disciform; disc cellulose or punctate, divided by imperfect septa into cuneate rays; centre hyaline; spines, one to each compartment. "This genus has the habit of Actinoptychus and Heliopelta, but differs from the former in the presence of lateral spines, and from the latter in the small number of these processes. The species of these three genera often closely agree in their form as well as in the number of their radii and cells; but the character of the spines will always distinguish them" (Bailey). "All the species of Omphalopelta resemble *Actynoptychus senarius*" (Kg.).

Heliopelta differs from this genus in having two or more spines instead of one to each compartment,—a difference we regard as more suitable for specific than generic distinction; and we believe that a better knowledge of these forms will prove the propriety of uniting them.

OMPHALOPELTA *cellulosa* (E.).—Radiating compartments 6, cellulose, alternately tumid and depresed, stellato-punctate; rays but slightly prominent; rim broad, striated. KA. p. 133. Fossil. Bermuda, Virginia. Diam. 1-192". This species greatly resembles the 6-rayed form of *Heliopelta Metii*, in which the compartments have sometimes only 1 and 2 spines alternately; and indeed we are not certain that they are even specifically distinct.

O. *areolata* (E.). — Compartments 6, all loosely and obscurely cellulose, scarcely or but slightly depressed; rays distinct; rim broad, radiate. EM. pl. 35 A. 18. f. 12. = *Actinocyclus areolatus*, Bri MJ. viii. p. 93, pl. 5. f. 1. Fossil. Bermuda, guano. (VIII. 15.)

O. *versicolor* (E.).—Compartments 6, all granulated in very fine decussating lines, which cause a play of colours from tawny to red; the strong rays and hexagonal crystalline umbilicus very conspicuous; rim narrow, radiant. KA. p. 133. Fossil. Bermuda. Diam. sometimes 1-252", but mostly less.

O. *punctata* (E.).—Radiating compartments 6, all loosely punctated, 3 alternate ones slightly elevated; rim narrow, not distinctly radiant; spines obsolete. KA. p. 133. Fossil. Bermuda.

Genus ARACHNOIDISCUS (Deane).—Frustules disciform; disc with a central hyaline nodule or umbilicus, and numerous radiating lines connected by concentric lines or series of gemmaceous granules. = Hemiptychus (E.). The disc has been compared to a spider's web; hence the name. Alternating with the long radiate lines are one to three short marginal ones, the central one of these being also longer than the other two when three are present. Professor Bailey informs us that Arachnoidiscus has been adopted instead of Hemiptychus because the latter name had previously been used in entomology.

ARACHNOIDISCUS *ornatus* (E.).—Disc having its radiating lines connected by concentric ones. = *Hemiptychus ornatus*, EB. 1848, p. 7; *Arachnoidiscus ornatus*, EB. 1849, p. 64; Ar TM. vi. p. 16; *A. Japonicus*, Shadbolt; *A. Nicobaricus*, EM. pl. 36. f. 35 (according to Arnott). Africa, West Coast of America, Nicobar Islands. (XV. 18–21.) In deference to the opinion of Prof. Arnott, we have united *A. Nicobaricus* to this species; but it is desirable to examine specimens from the original stations. Ehrenberg describes all the radiating lines in his *A. ornatus* as equal; but he figures *A. Nicobaricus* with two sets of shorter, marginal, intermediate ones. Our specimens, in this respect, agree with *A. Nicobaricus*, but have around the umbilicus a circlet of close, short, radiant, oblong lines, which are wanting in Ehrenberg's figure. The granules, too, are apparently larger in our specimens. The lines connecting the radiating ones often anastomose.

A. *Ehrenbergii* (Bailey).—Disc with numerous, moniliform, concentric circles of large pearly granules, the circle next the umbilicus formed of short lines; radiating lines with two series of shorter ones between. = *A. Ehrenbergii*, EB. 1849, p. 64; SD. i. p. 26, pl. 31. f. 256. Recent, Coast of Oregon and California; fossil, Monterey and California. *A. Ehrenbergii* is easily distinguished from *A. ornatus* by the absence of concentric lines. It is more hyaline, and the granules far larger and more conspicuous. All the circles are compact, and, except the two inner ones, have the granules slightly quadrate, and their relative distances somewhat irregular. The secondary rays are sometimes half the length of the principal ones; the third series is simply marginal.

A. *Indicus*, EM. pl. 36. f. 34. India. We have seen neither specimen nor description of this species. Ehrenberg's figure represents the disc with numerous, concentric, moniliform circles of pearly granules. The granules are distant in the first and third from the umbilical space; in all the others they are dense. Professor Arnott (perhaps rightly) unites *A. Indicus* to *A. Ehrenbergii*; but we have thought proper to keep them separate for the present, in order to direct more attention to them, because Ehrenberg's figure of *A. Indicus* differs in some respects from *A. Ehrenbergii*. In this species there is no linear series round the umbilicus, the third circle has distant granules, all the granules are orbicular, there is only one series of shorter rays interposed between the long ones, and these are connected by an undulated line, giving the inner margin of the rim a scolloped appearance. In all these respects it differs from *A. Ehrenbergii*.

Genus PERITHYRA (Ehr.).—Characters unknown to us. According to Ehrenberg's figures, it seems to differ from Heterostephania by its larger tubercles.

PERITHYRA *denaria*, EM. pl. 35 A. 9. f. 5. = *Coscinodiscus radiatus*, var., Wallich, TMS. viii. pl. 2. f. 22? Ganges. Disc with radiating series of minute puncta, ten intramarginal tubercles, a rather broad, smooth rim, and no umbilicus. (VIII. 19.)

P. *quaternaria*, EM. pl. 35 A. 9. f. 6. Ganges. A variety of the preceding, with only four tubercles.

FAMILY IX.—EUPODISCEÆ.

Frustules simple, free, disciform; lateral surfaces furnished with processes. The Eupodisceæ may be regarded as connecting the Coscinodisceæ with the Biddulphieæ. They agree with the former in their discoid frustules and with the latter in having processes on the lateral surfaces. These processes, however, must not be confounded with the spines or teeth which occur in some of the Coscinodisceæ. It is sometimes difficult to decide whether the discs really have processes or only pseudo-nodules, since, from their circular outline and hyaline texture, free from cellules, both these appear like orifices unless seen in profile, and perhaps Actinocyclus would be more correctly placed in this family than with the Coscinodisceæ.

Genus EUPODISCUS (Ehr.).—Frustules disciform; disc cellulose or granulate, furnished with submarginal circular prominences. = Tripodiscus, Tetrapodiscus, Pentapodiscus (E.), Podiscus (Bail.). The cellular structure is usually less evident in this genus than in Coscinodiscus. We have removed to Actinocyclus three species originally placed here by Professor Smith, who himself admits that they probably belong to that genus, "as the process in all is rather a pseudo-nodule than a projection from the surface of the valve."

EUPODISCUS *Argus* (E.). — Disc with three or more processes, subremote from the margin; cellules somewhat stellate, intervals punctated. SD. i. p. 24, pl. 4. f. 39. = *E. Americanus*, EB. 1844; *E. quaternarius*, *E. quinarius*, *E. Germanicus*, KA. p. 134. (VI. 2; XI. 41, 42.) Recent in marine and brackish water, Europe, America; fossil, United States. This species is easily recognized by its irregular cellules and intervening puncta, which give to the disc a clouded appearance, very unlike the usual transparency of Diatomaceæ. The processes vary from 3 to 5 in number. "The star-shaped cells appear when seen by direct light to be placed in the centre of small bosses or protuberances, in which respect it differs from all other Diatomaceæ that I am acquainted with. Ro MJ. ii. p. 73.

E. *monstruosus* (E.).—Disc with 4 processes on one side. E. *l. c.* p. 81. Baltic. Distinguished by the unsymmetrical disposition of its processes. It is probably an accidental variety of *E. Argus.*

E. *Rogersii* (Bail., E.). — "Frustules large, having 3 to 7 hyaline lateral processes placed on an elevated circle, within which the disc is slightly concave, and outside of which the surface is part of the frustum of a cone. = *Podiscus Rogersii*, BAJ. xlvi. pl. 3. f. 1, 2; *Eupodiscus Rogersii*, E. *l. c.*; *E. Baileyii*, E. *l. c.* Recent and fossil. United States. In this species the processes are close to the rim. The whole surface is beautifully punctate. . . . As this species is the largest and most beautiful of the fossil Infusoria occurring in the strata of which Professor W. B. Rogers made the discovery, I have selected it as peculiarly appropriate to bear his name" (Bail. *l. c.*).

E. *radiatus* (Bail.).—Disc plane, areolation hexagonal, with 4 (or more) submarginal processes. "Resembles *Coscinodiscus radiatus* in size and reticulation," BC. Bri MJ. viii. p. 95, pl. 5. f. 10. America.

Genus AULACODISCUS (Ehr.).—Frustules disciform; disc granulated, and furnished with intramarginal, shortly tubular processes, each connected with the centre by a distinct furrow, or by a radiant series of more conspicuous granules. Aulacodisci are Eupodisci furnished with bands radiating from the centre and connected with the tubercles situated just within the margin, and having the surface of their valves granulate, and not cellular. Professor Kützing makes this genus a section of Eupodiscus.

* *Disc bullate beneath the processes.*

AULACODISCUS *Petersii* (E.). — Disc nearly colourless, having a small, perforation-like umbilicus, a large kite-shaped inflation, rough with minute points, beneath each process, and minute granules arranged in lines. EB. 1845, p. 361. = *Eupodiscus Petersii*, KSA. p. 135; *E. cruciger*, Sh TM. ii. pl. 1. f. 12. South Africa, both recent and in guano; Australia and New Zealand. Disc large, with 3 to 5 orbicular processes, furnished with a central nipple and situated on the outer margin of the inflations. The granules are minute, and arranged in lines, some radiant and bisecting the intervals between the processes, the rest oblique and decussating. Raised points are present on the inflations and less conspicuously along the connecting furrows and about the umbilicus; margin finely striated. In order to observe the disc properly, it is necessary, on account of its unevenness, to vary the focus. Specimens from New Zealand have the granules and markings more distinct, and the inflations smaller, less definite, and further from the margin.

A. *formosus* (Arnott, MS.).—Disc lurid, having an irregular perforation-like umbilicus, a large cuneate inflation beneath each process, and radiating series of conspicuous pearly granules. = *A. Brightwellii*, Ralfs, MS.; *A. Boliviensis*, Bréb. MS. In upper Peruvian or San Filipe guano. *A. formosus* agrees with *A. Petersii* in having an inflation beneath each process, but differs in most other respects. From *A. margaritaceus* and *A. Comberi*, which it more nearly resembles in the appearance and arrangement of its granules, it is easily known by its inflations. Disc large, smoke- or lead-coloured, with a narrow, distinct, finely striated rim; inflations remote from the margin, and having a bright point at the outer edge, placed at the base of an elongated, clavate, not very conspicuous process.

2* *Disc not bullate beneath the processes.*

A. *scaber* (Ralfs, n. sp.). — Disc with oblong submarginal processes, crowded radiating series of minute granules, and scattered raised points. Peruvian guano. Processes 3 to 5, connected by indistinct grooves with the very minute umbilicus. In the front view this species resembles a Cerataulus, its lateral portions being turgid, and, in addition to the processes, rough with minute apiculi; connecting zone marked by faint longitudinal lines.

A. *Kittoni* (Arnott, MS.).—Disc hyaline, with 3 to 8 submarginal crescent-looking processes, connected by radiant rows of minute granules, with an umbilical rosette of oblong cellules. Recent, New Zealand and Monterey Bay; fossil, Monterey stone. An elegant species, distinguished by its somewhat mammiform processes, which, being directed outwards, appear lunate. Granules punctiform, proceeding from umbilicus to processes in pencil-like rays; interval between the processes bisected by similar pencils, but less conspicuous, and without furrows; the rest of the granules in oblique lines, as in *A. Petersii.*

A. *Johnsonii* (Arnott, MS.).—Disc pale, with a circular, perforation-like umbilicus, and crowded radiating series of granules becoming more numerous as they proceed outwards, so as to appear forked; processes within the margin, roundish, small. Algoa Bay guano. The rays, near the margin, become more numerous, with smaller granules, so as to look like striæ; sometimes the processes appear within a faint circle. *A. Johnsonii* somewhat resembles *A. Kittoni*, but is less hyaline, with more conspicuous granules, and processes more distant from the margin.

A. *Crux* (E.).—Disc with close, radiating, forked series of large pearly granules, which are crowded at the centre, leaving no blank space; processes somewhat distant from the margin. = *A. Crux*, EB. 1844, p. 76; EM. t. 18. f. 47; *Eupodiscus Crux*, KA. p. 135. Fossil. Virginia. We are indebted to Professor Arnott for correcting the error we had fallen into, of confounding it with *A. Kittoni.* In general appearance it agrees with *A. Comberi* and *A. margaritaceus*; but the processes are more remote from the margin, and the connecting furrows obscure; it differs essentially from most other species in having large granules at the centre of its disc, instead of a blank space; margin striated.

A. *margaritaceus* (Ralfs, n. sp.).—Disc pale, with oblong submarginal processes, an irregular, perforation-like umbilicus, numerous, close, moniliform, radiating series of large, pearly granules, and inconspicuous connecting furrows. Patos or Californian guano. = *A. Crux*, EM. pl. 35 A. 16. f. 2. Disc large, with from 3 to 10 rather small processes; umbilicus usually irregular, hyaline, looking as if denuded of granules, sometimes very minute and surrounded by a circlet of larger granules. Two simple series of equal granules lead to each process, beneath which, by a slight separation, they leave a triangular hyaline space; the other series are dichotomously divided, and near the margin their granules become smaller, or even punctiform, and resemble striæ.

A. *Comberi* (Arnott, MS.).—Disc lurid; granules large, irregularly scattered round the irregular perforation-like umbilicus, the rest arranged in crowded, forked, radiating lines; processes oblong, submarginal, with conspicuous connecting furrows. San Filipe guano. Processes 2 to 6. *A. Comberi* in character approaches closely to *A. margaritaceus*; its granules, however, are smaller and more irregular near the umbilicus, and the furrows leading from the processes are much more conspicuous; but the most obvious distinction of this species is its lurid appearance.

A. *Beeveriæ* (Johnson, MS.). — Disc smoke-coloured, with an irregular blank umbilicus, rather distant radiating lines of large pearly granules, striated margin, and (3 or 4) roundish submarginal processes. New Zealand. Of this beautiful species we have seen only one specimen. The disc is small, apparently nearly flat, with very distinct granules, 9 or 10 in ·001", on a dark ground; two series leading to each process, wider apart and more parallel than the rest. (VI. 5.)

A. *Brownii* (Norman, MS.). — Disc coloured, with a minute umbilicus, close radiating series of granules, and two or three roundish intramarginal processes. Shell-cleanings, California and elsewhere in the Pacific. Fossil, Monterey stone. Disc small under a low power, bluish, with a darker, brownish border. The granules, which, according to Mr. Norman, are about 17 in ·001″, are so regularly arranged as to form concentric circles as well as radiating series. *A. Brownei* agrees in colour with *A. Oreganus*, but in the arrangement of its granules more resembles *A. Beeveriæ*. From the former it differs in the regular radiant arrangement of its granules, smaller size, fewer processes, and much flatter surface. From *A. Beeveriæ* it is distinguished by its colour and closer granules.

A. *Oreganus* (Bailey).—Disc coloured, with circular perforation-like umbilicus, convex centre, flattened border, short cylindrical slightly emarginate marginal processes, and series of minute crowded granules. Bail. Proc. Acad. Philadelphia, 1853; Grev MJ. vii. p. 156, pl. 7. f. 2. California, both recent and fossil; Monterey stone, Puget's Sound. This very distinct species is easily recognized by its coloured disc and cylindrical emarginate processes, which are from 6 to 27 in number, and close to the margin. Under a low power its minute granules appear arranged in waved or oblique lines, but imperfectly radiant under higher powers. (VI. 4.)

A. *pulcher* (Norman, MS.).—Disc large, coloured, with from 7 to 16 marginal processes; central granules irregularly scattered or crowded, the others in distinct, close, radiant rows. Fossil. Monterey stone. *A. pulcher* agrees with *A. Brownei* in its coloured, slightly and uniformly convex disc and radiant arrangement of granules. It differs from that species by its much larger size and more numerous processes. The most remarkable feature of this species is its granulose centre, in which respect, as well as in its radiant granules, it differs from *A. Oreganus*. Granules 12 in ·001″. (VIII. 28.)

Genus AULISCUS (Ehr., Bail.).—"Frustules cylindrical or discoid; lateral surfaces undulated, having two circular, flattened, mastoid, imperforate processes at some distance from the margin; umbilicus (generally present) smooth, circular, surrounded by a plumose arrangement of dots and lines; sides smooth" (BC. 1854.).

"The projections on one valve are usually on a line at right angles to that on which those of the opposite valve are placed" (B.). Kützing unites Auliscus with Coscinodiscus; but it seems more nearly allied to Eupodiscus.

* *Disc with a conspicuous circular umbilicus.*

AULISCUS *pruinosus* (B.).—"Disc with four sets of curved and sparsely punctate lines, two diverging from the large smooth umbilicus, while the other two converge round the large processes." BC. 1854, pl. 1. f. 5–8. Recent. United States. (VI. 1.) "Frustules large, discoid or cylindrical; edges bevelled, central portion in front view smooth or with longitudinal parallel lines" (B.). We have seen frustules of this species with 3 processes.

A. *punctatus* (B.). — Frustules like those of *A. pruinosus*, but their lines so crowded and closely punctate that the plumose arrangement is scarcely visible. BC. pl. 1. f. 9. United States. "This may prove a variety of the preceding; but the sparsely punctate surface of the one and the closely punctate surface of the other appear to offer a sufficient distinction between them" (B.).

A. *cælatus* (B.).—Disc with unequal, strongly marked lines proceeding from the margin towards the centre, but leaving a well-defined central, four-lobed or cruciform figure, with waved lines radiating in four sets from the umbilicus. BC. pl. 1. f. 3, 4. In sand from West Indian sponge, and in soundings from Mobile Bay. Umbilicus distinct, smooth, the lines proceeding from it towards the processes in converging curves, the others variously flexed and anastomosing.

2* *Umbilicus wanting or obsolete.*

A. *sculptus* (Smith).—Disc with unequal, strongly marked short lines, radiating inwards from the margin and leaving a well-defined central, four-lobed space, marked with four sets of fainter lines radiating from the centre. =*Eupodiscus sculptus*, SBD. i. pl. 4. f. 42; Bri MJ. viii. p. 94, pl. 5. f. 3. England. (VI. 3.) This species resembles *A. cælatus*, but has no umbilicus. We have not seen the striæ of the central quatrefoil so strongly marked as in Professor Smith's figure, but always much fainter than the marginal ones; indeed sometimes they are very indistinct.

A. *Americanus* (E.). — Disc with strongly marked lines, radiating inwards from the margin and leaving an irregular central space destitute of lines. EM. pl. 33. 14. f. 2. United States. The large processes, as well as the central space, are without the radiating lines of *A. sculptus*; but we think it probable that Ehrenberg's figure was taken from a specimen of that species in which those markings were more than usually inconspicuous.

A. *cylindricus* (E.).—Frustules cylindrical, with a plane orbicular disc on each side, having a rim and a central area marked by various radiating lines; processes resembling oblique openings.

A. *ovalis* (Arnott, MS.). — Disc oval, with two opposite, narrow, hispid elevations midway between the roundish perforation-like apices of the processes; curved lines punctate, rather faint; umbilicus obsolete. Algoa Bay and Peruvian guanos. Communicated by Mr. Kitton. This species is distinguished by its oval disc and hispid elevations. The truncated processes do not in general correspond exactly with the longer diameter of the valve, but are placed a little on one side in opposite directions, in which respect, as well as in the presence of hair-like spines, it approaches Cerataulus.

Doubtful Species.

A. *polystigmus* (E.).—Radiating series of cellules converging in two lateral obsolete whorls, which appear perforated (processes ?). Cellules 14 in 1-1200″. Diam. 1-360″. = *Coscinodiscus polystigma*, KA. p. 124. North Sea.

A. ? *gigas* (E.).—Margin of sides tumid, looking as if perforated, sculptured by elegant rows of dotted, imperfectly radiant lines. EM. pl. 19. f. 63. = *Coscinodiscus Auliscus*, KA. p. 126. Fossil. Ægina. Ehrenberg's figure represents a mere fragment.

FAMILY X.—BIDDULPHIEÆ.

Frustules cellulose, compressed; lateral valves entering into the front view, and usually more or less produced, at one or both angles, into processes. The Biddulphieæ are remarkable for the great development of the lateral valves of the frustule, which are so convex or inflated as always to enter largely into the front view, causing the central zone to appear like a band between them. The mode of growth in this family is very interesting. Instead of simple elongation and subsequent division of the central zone by means of internal septa, new central and inner lateral valves are formed within the elongated original one, which, until ruptured, retains the frustules in pairs. The central zone is at first very narrow and merely a broad line, but it increases greatly in breadth until the new frustules are fully formed.

Genus CERATAULUS (Ehr.).—Frustules with turgid lateral valves, each valve with two tubular processes alternating with the same number of horn-like spines; lateral view orbicular or broadly oval. Cerataulus seems, in some measure, to connect the Biddulphieæ with the Eupodisceæ, since, in a lateral view, it approaches the latter in the circular form of some of its species; the front view, however, is similar to the other genera of this family: the frustules are binately conjoined by an external punctated sheath, and their processes are definite in number. Ehrenberg describes the frustules as simple, by complete fission; but Professor Bailey finds them concatenate. Cerataulus is characterized by having stout horn-like spines, which are not situated on protuberances between the two processes, but alternate with them, and form part of the same circle.

Cerataulus *turgidus* (E.). — Processes short, broad, and truncate; lateral valves broadly elliptic, with a submarginal band of apiculi. EB. 1843, p. 270. *Biddulphia turgida*, SBD. ii. p. 50, pl. 62. f. 384; Ro TMS. vii. p. 17, pl. 2. f. 23. Europe, America. Professor Bailey thus describes this species:—" Frustules globular or slightly compressed, with two large prominences at each end, cohering by alternate angles, forming zigzag chains. Between the two processes, and in a plane at right angles to that containing them, are placed two long horn-like processes. Two frustules are often connected by an external decussately punctate cell, as in Isthmia and Biddulphia." The processes do not exactly correspond with the angles, but are situated a little to the side in opposite directions. This species, beautifully figured in Professor Smith's excellent work, is easily recognized by its broad, truncated processes. (VI. 8.)

C. *Smithii* (Ra.).—Valves in front view turgid; processes conic, alternating with subulate horn-like spines; lateral valves orbicular; cellules distinct. = *Eupodiscus radiatus*?, SBD. i. p. 24, pl. 30. f. 255 (not Bailey); *Biddulphia radiata*, Ro TMS. vii. p. 19, pl. 2. f. 27–29. Thames. The orbicular form and differently shaped processes distinguish this species from the preceding. The cellules are not radiant; and as Professor Smith's name was bestowed in error, and is liable to mislead, we have thought it advisable to change it.

C. *lævis* (E.). — Frustules large, quadrangular, with short, broad, truncate processes and straight intermediate margin; valves suborbicular, obscurely punctate, with two minute, opposite, submedian spines. = *Biddulphia lævis*, EB. 1843, p. 122; Ro MJ. vii. p. 18, pl. 2. f. 24–26; *Odontella polymorpha*, KB. 1844, pl. 29. f. 90; *Isthmia polymorpha*, Montague. Shores of North and South America. (VI. 7.)

C. *thermalis* (Me.).—Large, joints cylindrical, angularly concatenated by a lateral isthmion; lateral valves very smooth. = *Melosira* (*Pleurosira*) *thermalis*, Menegh. 'On the Animal Nature of Diat.,' p. 391. Warm springs of Euganja. Length of frustules very variable. Kützing refers this to the preceding species, —a decision from which Meneghini dissents. The following extracts are taken from the work of the latter:—"Kützing says, 'Your *Melosira* (*Pleurosira*) *thermalis* is in no respects different from the *Odontella polymorpha*. I have compared your specimen with that of Montague. There are even found the delicate points upon the shield, as in the other, which I have inadvertently omitted in my figure. Your specimen is certainly an Odontella, although the articulations are cylindrical.'" On this opinion Meneghini makes the following comments:—"Although I have had an opportunity of examining fragments only of Montague's *Isthmia polymorpha*, I am positive in treating the matter differently. It is admirably figured by Kützing; the articulations are not cylindrical, and, though obtuse and slightly prominent, the lateral processes are very evident." For other distinctions between them, see the work quoted, p. 483.

Genus BIDDULPHIA (Gray). — Frustules compressed, quadrilateral, cohering by their alternate angles, and thus forming a zigzag chain; angles equal, elongated into tooth-like projections; spines none, or confined to the intermediate rounded projections; lateral valves constricted laterally at their base. Great difference of opinion exists as to the proper arrangement of the forms here associated, whether they should be included in a single genus or not. Ehrenberg and Kützing distribute them in two genera; but although their genera appear identical, yet their definitions differ so much as to make the agreement in fact merely nominal. Professor Smith unites Cerataulus and Zygoceros, as well as Odontella, to Biddulphia, whilst Professor Bailey, whose opportunities of studying this family have been so ample, admits the propriety of conjoining Biddulphia and Odontella, but is not prepared to add Zygoceros. Brébisson, who first conjoined Biddulphia and Odontella, subsequently recognized both genera. Ehrenberg and Kützing concur in describing Biddulphia and Odontella (Denticella, *E.*) as concatenate, and Zygoceros and Hemiaulus as simple. Ehrenberg distinguishes Biddulphia from Odontella by the absence of spines, which are present in the latter. Kützing, on the other hand, characterizes Odontella as smooth (not cellulose, though often punctate or granulate), without internal septa, and Biddulphia as regularly punctato-cellulose, with internal septa. Smith finds spines in the typical species of Biddulphia; and Bailey considers the presence or absence of spines an unimportant accident. We retain our former opinion, that we cannot exclude any species from Biddulphia merely on account of the absence of costæ, without violating natural affinity, and dividing Isthmia also. In Biddulphia, Kützing forms his species solely from the number of lateral costæ and consequent divisions (chambers); his species, however, have been generally rejected; and we think that, like similar characters in Actinoptychus and other genera, such distinctions are essentially erroneous.

* *Valves with undulating margins and transverse costæ or depressions.*

BIDDULPHIA *pulchella* (Gray).—Frustules distinctly reticulated; valves with obtuse processes, and from one to five smaller intermediate projections separated by costæ extending to the suture. SD. ii. p. 48, f. 321. *B. trilocularis*, Kütz. (with two costæ); *B. quinquelocularis*, Kütz. (with four costæ); *B. septemlocularis*, Kütz. (with five costæ); *Denticella Biddulphia*, E. (central projection armed with spines); *B. australis*, Montague; *B. elongata*, Montague (with broad central portion). (II. 46 to 50.) The distinctive character of this species is the costæ or imperfect septa which separate the projections. Lateral valves oval, with undulated margins and a large pseudo-opening at each end. In the young state there is only one rib, and no intermediate projection.

B. *Regina* (Sm.).—Valves with three median elevations, the central one largest, unarmed; processes little exceeding the median elevation in length, papillate, rounded; cellules of elevation distinct, those of valves and central zone minute. SD. ii. p. 50, pl. 46. f. 323; Ro TMS. vii. p. 8. Dredged off the Island of Skye. Professor Bailey refers this species to *B. tridentata*, and Professor Williamson, according to Professor Smith, to *B. Tuomeyi*. We have seen no specimen, but trust to the well-known accuracy of Professor Smith's figures for its distinctness in the form and comparative shortness of its processes.

B. *tridentata* (E.). — Lateral valves dotted, having elongated, obtuse processes, and one to three unequal intermediate projections; constrictions approaching the suture. EM. pl. 19. f. 21. = *Denticella tridentata*, E. (central protuberance armed); *Denticella Tridens*, E. Fossil. America. Professor Bailey refers *B. Regina*, Sm., to this species, but, judging from the descriptions and figures, they seem to us distinct. In this species the processes are more slender, longer than the intermediate projections, and mostly constricted beneath the apex. Mr. Roper unites this species to *B. Tuomeyi*, and is probably right in so doing.

B. *obtusa* (K.).—Frustules very smooth, short, with turgid, obtuse, short horns, and a very short intermediate process. = *Odontella obtusa*, KA. p. 136. Heligoland. (XIII. 30 to 32 A.)

B. *subæqua* (K.).—Frustules oblong, very smooth; horns minute, without intermediate projections. = *Odontella subæqua*, KB. pl. 18. 8. f. 4, 5. Heligoland. Professor Smith is probably right in regarding the last two as states of *B. aurita*.

B. *lævis* (E.).—Has the habit of *B. aurita*, but its valves are smooth and tridentate. = *Denticella lævis*, EM. pl. 33. 15. f. 6. Antarctic Sea. Diam. 432″. Ehrenberg's figure of this species but slightly resembles *B. aurita*: the horn-like processes are elongated, slender, and awl-shaped, and not the least inflated at the base; the intermediate margin also is convex, and not elevated into a central projection.

B. *Tuomeyi* (B.).—Valves having obtuse horns with swollen bases, between which are from one to three shorter, rounded projections, the middle one largest, and often bearing two spines. = *Zygoceros Tuomeyi*, BAJ. xlvi. pl. 3. f. 3 to 9. Fossil. America, Patos guano. (VI. 10.) The central zone is narrow-linear, and slightly projects at each end; lateral valves covered with shagreen-like asperities, which are most evident on the projections; processes generally constricted. At the base of each swelling is a short, linear, hyaline line which resembles a perforation, but which we believe is really a smooth elevation.

B. *polymera* (E.). — Lateral valves granulated, very broad and short; angles elongated into conical processes; intermediate projections several (about nine), rounded, the central one largest. = *Denticella? polymera*, E., BAJ. xlviii. pl. 4. f. 20; *Odontella? polymera*, K.; *B. Tuomeyi*, Ro TMS. vii. p. 8. Fossil. Bermuda. The lateral valves are so short that the constrictions between the lobes reach nearly to the base. This species is remarkable for the great number of intermediate projections, of which the central one is the largest, the others decreasing regularly on each side, two of them armed. Mr. Roper unites this form, probably correctly, with *B. Tuomeyi.*

2* *Valves lanceolate or elliptical, without undulated margins* (Odontella, *Ag.*).

B. *aurita* (Lyngb., Bréb.).—Frustules finely punctated; angles prolonged into slender conical horns, with an intermediate projection, which is usually furnished with a few spines; valves elliptic-lanceolate. SBD. ii. p. 49, pl. 45. f. 319. = *Odontella aurita*, Ag., K.; *Denticella aurita*, E.; *Denticella gracilis*, E. America, Africa, Europe.

B. *Roperiana* (Grev.).—Valve elliptical oval, with central elevation, which in front view is depressed or sometimes bilobed, punctate, unarmed; angular processes scarcely produced, obtuse, largely inflated at base; connecting zone with rows of minute granules, parallel with suture of the valve. Grev JMS. vii. p. 163, pl. 8. f. 11–13. Seaweed, Monterey; Californian guano. "This species appears to be removed from *B. aurita* and its varieties by the absence of spines, and the very depressed, often two-lobed central elevation of the valve" (Grev.).

B. *longicruris* (Grev.).—Valve in front view with central elevation, bearing a very long spine; angular processes very much produced, awl-shaped; surface minutely granulate. Grev JMS. vii. p. 163, pl. 8. f. 10. Californian guano; Sierra Leone.

B. *turgida* (E.).—Lateral portions in front view scabrous, with produced, conical, obtuse angles, and two distant, long, intermediate spines; valves elliptic-lanceolate. = *Denticella turgida*, EB. 1840, p. 207; *Odontella turgida*, KB. t. 18. f. 89; *Biddulphia granulata*, Ro TMS. vii. p. 13, pl. 1. f. 10, 11. Atlantic. Britain. Processes large, inflated at base, slightly recurved; spines generally slightly bent at the middle; valves rough with minute apiculi.

B. *reticulata* (Ro.).—Valves hirsute, with large hexagonal reticulations; processes obtuse, subconic, inflated and gibbous at the base. Ro TMS. vii. p. 14, pl. 2. f. 14–17. Ceylon, Natal, New Zealand. Valves elliptic; connecting zone having rows of rather conspicuous dots.

B. *Indica* (E., Ro.).—Valves hirsute, with slender, elongated, subcapitate processes, and a long awl-shaped spine near each process. Ro TMS. vii. p. 16, pl. 2. f. 20–22. = *Denticella Indica*, ERBA. 1845, p. 362. Natal. (VI. 12.) Valves lanceolate, with the pseudo-apertures at right angles to the length of the valve, Roper.

B. *tumida* (E., Ro.).—Valves broadly elliptic, with very fine radiating dots, and two or three submarginal spines; in front view globose, with tapering obtuse processes. Ro TMS. vii. p. 15, pl. 2. f. 18, 19. = *Denticella tumida*, ERBA. 1844, p. 266; *Odontella tumida*, KSA. p. 137. Bermuda; Californian guano.

B. *Macdonaldii* (Norman, MS.). — Frustules finely striated, with very short, nearly obsolete processes; valves with transverse striæ interrupted by a median line. Shark's Bay, Australia. (VIII. 23.) Valves minutely dotted between the striæ; frustules somewhat twisted. For the description of this species we are indebted to G. Norman, Esq.

Doubtful or imperfectly known Species.

B. ? *brevis* (E.).—Small, laterally lanceolato-rhomboid, smooth, tripartite with two septa; lateral portions also three-lobed; lobes small, subequal; pseudo-openings obsolete. KA. p. 138. Portugal.

B. ? *gigas* (E.).—Large, very turgid at the centre, rough, without distinct granules, laterally five-jointed, having a large, oblong (pseudo-) opening at each attenuated apex. KSA. p. 138. Fossil. Bermuda. Diam. 1-144″.

B. ? *lunata* (E.).—Valve three-lobed, smooth, slightly curved, lunate, with subacute horns. EM. pl. 18. f. 53. Fossil. Virginia. Diam. 1-864″.

B. ? *ursina* (E.).—Large, turgid, not cellulose; sides hirsute, not constricted, middle part smooth. KSA. p. 138, fragment. Antarctic regions. Diam. 1-192″. Remarkable for its hairiness.

B. ? *amphicephala* (E.).—Smooth, narrow, wand-like, concatenate, constricted beneath each apex; hence each end capitate, rounded. = *Odontella? amphicephala*, E. KSA. p. 137. Mouth of the Tagus. Individual frustules resemble those of *Navicula dicephala* in habit.

B. ? *Fragilaria* = *Denticella?* EM. pl. 21. f. 31. Algiers. Perhaps a fragment of *Eucyrtidium lineatum.*

B. ? *Cirrhus* (E.).—In Barbadoes earth. We have seen neither description nor figure of this species.

Genus PORPEIA (Bailey, MS.).—Frustules simple (?), compressed, each valve with two short obtuse processes, and two internal curved plates which do not extend to the central portion. We give this genus in deference to the opinion of our highly esteemed correspondent the late Professor Bailey, but doubt whether it is sufficiently distinct from Biddulphia. In Porpeia the septa appear like costæ incurved at their inner ends.

PORPEIA *quadriceps* (Bai. MS.).—Processes with punctated rounded ends, the intermediate margins slightly convex; lateral view narrow, with two constrictions, and rounded ends. Gulf-stream. (VI. 6.) From drawings by Professor Bailey. "At first sight this species suggests a relation to Grammatophora; but the curved plates run at right angles to their position in that genus (*i. e.* not parallel to the division of the frustules, but perpendicular to it)."—B. *in lit.*

Genus ZYGOCEROS (Ehr.).—Frustules free, compressed, not concatenated; each valve with two (apparently) perforated horn-like processes. Although we have retained this genus, yet we think it is very probable that a better knowledge of its species will justify Professor Smith in uniting it with Biddulphia, from which it differs only in its simple frustules.

ZYGOCEROS *Rhombus* (E.).—Frustules turgid, with a smooth or faintly punctated central portion; lateral valve rhomboid with rounded angles, its surface having very fine granulated striæ. = *Biddulphia Rhombus*, SBD. ii. p. 49, pl. 45. f. 320; Ro TMS. vii. p. 11, pl. 1. f. 4. America, Europe, England. *β*, valves with one or more median spines, = *Denticella Rhombus*, E.; *Odontella Rhombus*, K. Large; striæ 24 to 26 in 1-1150″. Diam. 1-720″. "Spines submarginal, awl-shaped, abbreviated" (Sm.).

Z. radiatus (B.). — Frustules large, turgid; lateral valve rhomboid, with rounded angles and radiating series of granules. BSC. vii. *Z. Balæna*, EM. pl. 35. A. 23. f. 17; Bri JMS. vii. p. 181, pl. 9. f. 15. Nova Scotia. "Akin in habit to *Z. Surirella*, but larger than *Z. Rhombus*. Central zone punctated" (Ehr.).

Z. Surirella (E.). — Frustules small; lateral valve lanceolate, with constricted obtuse apices; surface with transverse granular lines, interrupted by a median longitudinal band. Ro TMS. ii. pl. 6. f. 11, 12. Alive. Europe. Thames. (XI. 50, 51.) Diam. 1-720″. Central portion smooth, granules of valves more distinct than in *Z. Rhombus*. Distinguished by the smooth longitudinal line in a lateral view.

Z. Bipons (E.).—Frustules laterally lanceolate, with acute ends, and two smooth median constrictions; granules delicate, not radiant. KSA. p. 139. Bermuda deposit. Diam. 1-384″. Angles with small horns. May be known by having, in the lateral view, two transverse lines.

Z. stiliger (E.).—Frustules laxly cellulose; valves with double median constriction of the side; angles produced into long, acute, stiliform horns. KSA. p. 139. Fossil. Bermuda deposit. Diam. 1-1152″. "*Z. stiliger* may be a species of Hemiaulus; but the constrictions resemble those of Biddulphia, save that they want the wide apertures of the horns" (Ehr.).

Z. australis (E.).—Frustules smooth; horns obsolete; lateral valve turgid-lanceolate, with conspicuous pseudo-openings. KSA. p. 139. Antarctic Sea. Diam. 1-480″.

Z. ?Circinus (B.).—Frustules minutely and decussately punctate; lateral valves forming truncated cones without processes, but each having two long, setiform, bent spines; lateral view elliptic. BC. vii. pl. 1. f. 19, 20. Fossil. Virginia. Characterized by the conic outline of the lateral valves, and the absence of processes.

Z. Navicula, EM. pl. 19. f. 22. Fossil. Greece. Lateral valve oblong, with transverse rows of dots, a transverse smooth median band, and a pseudo-opening at each end.

Z. paradoxus (E.).—Smooth, laterally linear-oblong with rounded ends." EM. pl. 22. f. 54. = *Surirella paradoxa*, EM. Caltanisetta, Sicily. 1-576″.

Z. Siculus (E.). — Smooth, linear; laterally rhomboid, with obtuse ends. EM. pl. 22. f. 53. = *Surirella rhomboidea*, EM. Fossil. Sicily. 1-744″.

Z. Mobiliensis (B.). — Frustules quadrangular, thin, delicately punctate; valves with slender, tapering lateral processes, and two slight intermediate projections armed with one or two very long filiform spines. BC. 1859. = *Biddulphia Baileyii*, SBD. ii. p. 50, pl. 62. f. 322; Ro TMS. vii. p. 12, pl. 1. f. 5–9. America. In stomach of Ascidiæ. Hull, Teignmouth. (VI. 11.) Frustules fragile, yellowish. A well-marked species; there is no central projection of the valves, but two slight elevations, furnished with one or more bristles, and dividing the margin into three nearly equal portions. The elevations appear situated between the processes, but are really placed on opposite sides.

Genus HEMIAULUS (Ehr.).—Frustules compressed, subquadrate; fission perfect, hence not concatenate; valves without lateral constrictions, each with two processes—that of the one side (apparently?) open, the other closed. The genus has the habit of Biddulphia, but is devoid of the lateral constrictions. It has the form of a Pandean pipe. As the valves are not constricted, the basal angles are rectangular, and the outer margins of the processes (which are generally attenuated, narrow, and elongated) are straight.

HEMIAULUS *antarcticus* (E.).—Frustules strongly granular; lateral processes elongated, of one valve truncate, of the other elongated; a short median rounded projection between the processes. EM. pl. 35. A. 22. f. 15. Antarctic Sea. (XI. 54.) Diam. 1-1152″. Granules in parallel rows.

H. *Polycystinorum* (E.).—Angles extended into very long, narrow, linear, horn-like processes, which are attenuated at the extremity, and, as well as the base, cellulose. EM. pl. 36. f. 43. Barbadoes deposit. Between the processes are from one to three slight projections; lateral view oval, bordered, having transverse bars corresponding in number to the depressions.

H.? *Australis* (E.).—Valves strongly granulate; lateral processes rounded, intermediate one obsolete. KSA. p. 139. Antarctic Sea.

H.? *Californicus* (E.).—Valve granulate, having a subquadrate base; angles extended into linear processes without intermediate projections. EM. pl. 33. 13. f. 15. In Californian tripoli.

Genus ISTHMIA (Ag.).—Frustules compressed, trapezoidal, cellulose, attached, cohering by short neck-like processes, so as to resemble irregularly branched filaments. Frustules always more or less oblique, the lower angle of each prolonged into a process by which it coheres to the one beneath, and which in the basal frustule forms the stipes by which the filament is attached. The frustules are turgid, and the reticulations of the central portion smaller than those of the sides.

ISTHMIA *enervis* (E.).—Lateral valves with large, somewhat quadrate cellules arranged in transverse parallel lines. = *Conferva obliquata*, EB. t. 1869; *I. obliquata*, Ag.; *I. nervosa*, KSA. p. 135; E Inf. p. 209, pl. 16. f. 6; SBD. ii. p. 52, pl. 48. Europe, America, Cape of Good Hope, &c. (X. 183.) The lateral portions are separated from the central one by rather broad lines, produced by the junction and inflection of the margins, and which form internally projecting plates or rims. The cellules bordering the sutures are somewhat larger than the other cellules of the central portion, but less remarkably so than in the next species.

I. *nervosa* (K.).—Lateral portions with parallel transverse costæ, having two or more series of hexagonal cellules in each interval. = *Diatoma obliquatum*, Lyng.; *I. obliquata*, E.; *I. nervosa*, KA. 135; SD. ii. p. 52, pl. 47. Northern shores of Europe and America. This is usually a more northern species than *I. enervis*. The cellules are smaller, except a series of large conical ones bordering the inner side of the sutures, and the frustules are generally not so wide in proportion to their length; but the most evident distinction is the division of the lateral portions into compartments by the costæ, which often anastomose.

I. *minima* (Harv. & B.).—Central portion very finely decussately punctated; lateral portions granulated by large cellules. Proc. of Acad. of Phil. Rio de Janeiro and Sooloo Sea.

Imperfectly known.

I.? *Africana* (E.).—Large flat fragments resembling the central portions of

Isthmia, marked by transverse rows of very minute cellules. Oran, Africa. ERBA. 1844, p. 83. Diameter of largest fragment 1-216″.

Genus HYDROSERA (Wallich).—Frustules quadrate, united into filaments, and furnished with conspicuous horizontal bands or septa; valves cellulose, compressed, or triangular, with internal septa, and, on one side only, with minute, aperture-like appendages. Marine. Filaments elongated, attached, compressed, or prismatic. Joints rectangular, connected at the angles by mucous cushions, and marked by bands passing across the valves and connecting zone. In the lateral view the ends or angles are separated by septa. Hydrosera seems allied on the one hand to the Terpsinoëæ, and on the other to the Biddulphieæ and Anguliferæ.

HYDROSERA *compressa* (Wallich).—Filaments compressed; valve oblong, divided into three inflated compartments by two transverse septa. Wallich, MJ. vi. p. 252, pl. 13. f. 7–11. East Indies. Side view with blank angles, occasionally unfurnished with a few minute spines. (VI. 8.)

H. *triquetra* (Wallich). — Filaments triquetrous; valves triangular, with the subcircular centre divided from the obtuse, somewhat produced angles by septa. Wallich MJ. vi. p. 251, pl. 13. f. 1–6. East Indies. Front view with four transverse bands; valves with undulated sides, reticulated, except at the angles, which are furnished with a few extremely minute spines (VI. 13.)

FAMILY XI.—ANGULIFEREÆ.

Frustules cellulose or granulate; in lateral view angular. This family is closely allied to Biddulphieæ (and in some manner connected with the Coscinodisceæ and Eupodisceæ). As in that family, the lateral portions are seen, in the front view, having the central portion like a band between them. Hence, in order to determine their proper family, it is frequently necessary to see them laterally. The angles, however, in the front view are usually less elongated, and the intervening margin less lobed in the Anguliferæ than in the Biddulphieæ.

Genus EUODIA, n. g. (Bailey, MS.).—Frustules cellulose or granulate; in lateral view lunate. Euodia agrees with the Eunotieæ in the shape of its frustules, which can scarcely be called angular; yet, notwithstanding that resemblance in form, its punctate or granulate surface induces us to place it here.

EUODIA *gibba* (Bai. MS.).—Frustules in lateral view semilunate, the ends somewhat conical, the lower margin gibbose; surface with radiating series of minute granules. Recent. Gulf Stream. (VIII. 22.) From a drawing by Professor Bailey. The upper margin is very convex, the lower one less so. A contraction near the obtuse ends makes them appear somewhat produced and conical. Professor Bailey represents the cross section as cuneate. *Goniothecium anaulis*, EM. t. 33. 18. f. 4, greatly resembles this species, and may be identical. The upper margin, however, is represented as more convex, the ends less produced, and the granules larger and less numerous.

E.? *Brightwellii.*—Frustules semilunate, ends scarcely produced, lower margin concave; granules somewhat concentric. = *Triceratium semicirculare*, Bri MJ. i. p. 252, pl. 4. f. 21. Bermuda earth. *T. obtusum*, EM. pl. 18. f. 49, may probably be referred to this species.

Genus HEMIDISCUS (Wallich).—Frustules free; valves cellulose, arcuate, with a ventral marginal nodule; cellulation hexagonal, radiate. Marine. We doubt whether Hemidiscus be distinct from Euodia, since the only distinction seems to be the marginal nodule of the former,—a character perhaps overlooked by Professor Bailey.

HEMIDISCUS *cuneiformis* (Wallich).—Valves semilunate; venter with a marginal row of puncta, and slightly gibbous at the middle. Wallich, TMS. viii. p. 42, pl. 2. f. 3, 4. Bay of Bengal and Indian Ocean. Cellulation distinct, largest at the centre. Connecting zone broadest at the dorsum. (VI. 14.)

Genus TRICERATIUM (Ehr.).—Frustules cellulose, free, simple; in lateral view triangular (rarely with four or five angles). This genus has been well illustrated by Mr. Brightwell in his excellent monographs published in the 'Journal of Microscopical Science;' so that the species can be distinguished without much difficulty. His discovery, in more than one species, of frustules with four or even with five angles, shows that in this, as in several other cases, the number of parts do not afford good generic distinctions. We were inclined to place greater reliance upon their complete fission; but Professor Bailey informed us that he had met with catenate specimens. Mr. Brightwell, indeed, says that "the projection of a connecting membrane (central portion) beyond the suture of the valve, which is one of the characters of the genus Amphitetras, is not seen in the square forms of Triceratium;" but we greatly doubt the validity of this distinction. "One of the difficulties attending the study of this genus, and the determination, especially in the fossil forms, of the species, arises from the difficulty of obtaining perfect frustules, and examining them in their front aspect. The imperfect frustules present only the end or triangular wall, from which alone no perfectly satisfactory specific character can be obtained" (Br.).

The descriptions, unless otherwise specified, apply to the lateral view of the frustules, and are drawn up, with few exceptions, from Mr. Brightwell's monographs.

* *Lateral surfaces spinous.*

TRICERATIUM *spinosum* (B.).—Sides nearly straight; angles prolonged into horn-like processes; granules minute; spines numerous; front view constricted beneath the processes. Silliman's Journal of Science, xlvi. pl. 3. f. 2. = *T. setigerum*, BC. 1854, pl. 1. f. 24; *T. armatum*, Ro MJ. ii. p. 283; *T. tridactylum*, Bri MJ. i. p. 248, pl. 4. f. 3. Fossil, America; recent, England, Florida. (VI. 19.) A variable species; its numerous spines and somewhat triradiate form best distinguish it. Larger spines are often interspersed among the smaller ones.

T. *compactum* (Bri. MS.). — Spinous; front view constricted beneath the somewhat inflated processes; central portion bordered by a series of large cellules. = *T. armatum*, *β*, Bri MJ. iv. p. 274, pl. 17. f. 11. Recent. Australia. Smaller than *T. spinosum*, but like it in form, having a spine on the middle of each side. In the front view it is very different.

T. *coniferum* (Bri.). — "Sides irregularly concave; angles drawn out into an extended cone with a short, stout horn near each; centre of frustule convex, with three setæ." Bri MJ. iv. p. 274, t. 17. f. 6. Shell cleanings. The mammillate angles, giving the sides a waved appearance, mark the species. The granules are not radiant.

T. *contortum* (Sh.).—Angles prolonged into curved horn-like processes; spines in three radiate double rows, terminating near each angle with a long bristle. Sh TMS. ii. p. 15, pl. 1. f. 7. Recent. Natal. (VI. 18.) Well distinguished by its contorted angles. Sides straight.

T. *orbiculatum* (Sh.).—Sides convex; angles obtuse, each with a circular pseudo-nodule accompanied by a spine; granules minute, radiating. Sh TMS. ii. p. 15, pl. 1. f. 6. Natal. The front view shows the narrow central portion marked like the lateral portions, which are large, not constricted, and terminated by three truncated cones. Mr. Brightwell entertains no doubt as to the identity of his specimens with Mr. Shadbolt's species; yet the latter's figure has no spines, and he describes "the margin being so inflated as to cause the triangular outline to approach that of the circle."

T. *Marylandicum* (Bri.).—Sides nearly straight, with rounded angles, without pseudo-nodules; granules minute, radiating from an angular umbilicus; spines few, marginal. Bri MJ. iv. p. 275, pl. 17. f. 17. Maryland deposit. There is at each angle a short spine, and sometimes another at the middle of each margin. Professor Bailey regards this species as identical with *T. Amblyoceros*; but we cannot believe that Ehrenberg would have omitted so remarkable a character as the angular umbilicus, nor are both species found in the same deposit. We have already given our reasons for doubting the correctness of the supposition that Ehrenberg founded his *Symbolophora Trinitatis* upon this species.

T. *annulatum* (Wallich).—Valve minute, with slightly produced rounded angles and concave sides; surface marked with concentric rings, and a ray proceeding from the centre towards each angle. Ganges. Wallich, MJ. vi. p. 249, pl. 12. f. 15. Valves covered with minute puncta, aggregated into concentric rings.

2* *Lateral surfaces with radiating vein-like lines.*

T. *radiatum* (Bri.). — Sides straight; angles obtuse; radiating lines most evident at centre and margin; granules minute, radiating. Br. *l. c.* p. 275, pl. 17. f. 14. Barbadoes deposit. Frustules large, without horn-like processes.

T. *marginatum* (Br.). — Valves with a triangular centre, which is surrounded by a broad border divided into compartments by short transverse lines. Br MJ. iv. p. 275, pl. 17. f. 13. Fossil. Sides straight, angles with double pseudo-nodules; granules of centre minute, radiating, those of compartments larger and scattered.

T. *venosum* (Br.). — Sides concave; angles rounded, surface dotted, and marked by three radiating pinnated lines or veins. (VI. 17.) Br MJ. v. p. 274, pl. 17. f. 5. Barbadoes deposit. A very beautiful and distinct species.

T. *tabellarium* (Br.).—Margin indented in foliaceous curvatures; granules numerous near the margin, elsewhere in patches; angles with small horns. Br MJ. iv. p. 275, pl. 17. f. 15. Honduras. This species is well distinguished by its scolloped margin. It is doubtful whether it is properly placed in this section.

T. *variabile* (Br.). — Surface with a transverse line below each angle, and some irregular radiating veins; granules scattered, indistinct at the angles. Br MJ. iv. p. 275, pl. 17. f. 19. Peruvian guano. Resembles *T. alternans*, but is larger and generally distorted; the angles are conical. Mr. Brightwell figures a quadrangular form of this species.

T. *truncatum* (Br.).—Angles elongated into broadly truncate arms, centre divided into granulated compartments by radiating vein-like lines. Br MJ. iv. p. 274, pl. 17. f. 4. Barbadoes earth. Frustules triradiate.

3* *Lateral surfaces with transverse lines separating the angles from the hexagonal centre.*

T. *brachiatum* (Br.).—Triradiate; angles elongated into truncate arms, and separated from centre by transverse lines. Br MJ. iv. p. 274, pl. 17. f. 3. Barbadoes earth. Distinguished by its angles prolonged into rays. It resembles *T. truncatum* in form, but is smaller, and has no radiating veins.

T. *alternans* (Bai.). — Sides straight, angles obtuse, granulated like the hexagonal centre. SBD. i. p. 26, pl. 5. f. 45. Common, recent and fossil. England, United States guano. (VI. 21.) Front view quadrate, not constricted; the angles not prolonged into processes.

T. *trisulcum* (Bai. MS.). — Sides very concave; angles broadly rounded, separated from centre by transverse lines; granules crowded and very minute at angles, elsewhere few, large, and scattered. (VIII. 27.) From a drawing by Professor Bailey. Gulf-stream shells, W. Indies. This species may be known by its distant granules.

T. *castellatum* (West).—Sides of the frustule deeply concave; angles forming segments of circles. Valves with concave sides and rounded angles, forming dome-shaped eminences; surface punctate, with a single row of larger puncta along the opposed margins. West, TMS. viii. p. 148, pl. 7. f. 3. Barbadoes deposit. (VIII. 29.)

T. *Johnsoni* (Ralfs, n.s.).—Valves with rounded angles and concave sides, surface with scattered granules, and a large granulated space at the angles, separated by a transverse smooth band; margin with a few short lines. Barbadoes deposit. Johnson. Valves large, with conspicuous granules, which are few at the centre, and more numerous near the margin; each side with a few short striæ like those figured by Mr. Brightwell in *T. tabellarium*, but the margin itself is not undulated.

T. *umbilicatum* (Ralfs, n.s.).—Valves

with broadly rounded angles and deeply sinuated sides, triangular smooth umbilicus, radiant series of close granules, and a large punctate space at each angle. Barbadoes deposit. Johnson. This large and beautiful species is distinguished by the sinuated sides and triangular umbilicus of the valves. Granules conspicuous and dense, appearing both radiant and concentric. The large angles are separated by indistinct transverse lines, and appear smooth or granulated according as they are more or less in focus, and they have a central round spot (probably a process) and striated margin. This species differs from *T. castellatum* in a distinctly radiant arrangement of the granules and a smooth umbilicus.

T. *megastomum* (E.).—Sides straight; angles obtuse, with pseudo-nodules, and separated by transverse lines from the hexagonal centre. EM. pl. 35. In guano. Small, somewhat resembling *T. Reticulum*, but differing in its pseudo-nodules and hexagonal centre.

4* *Sides in lateral view gibbous or undulate (angles without pseudo-nodules; cellules minute).*

T. *undulatum* (E.). — Sides slightly convex, undulated; granules minute, radiating. Br MJ. i. p. 250, pl. 4. f. 13; ERBA. 1840, p. 273. Fossil. Bermuda and Virginian deposits.

T. *Brightwellii* (West). — Sides of valves undulate, slightly convex, or straight; granules minute, radiating from the centre, from which proceeds a spine of considerable length; margin of valve closely set with short spines. = *T. undulatum*, Br MJ. vi. p. 154, pl. 8. f. 1–5, 8; West, TMS. viii. p. 149, pl. 7. f. 6. Var. β with 4 angles. In Noctilucæ. England. The discovery of this and the following species in a living state has explained the appearance of the central pseudo-nodule, which has proved to be the remains of a long horn or spine.

T. *intricatum* (West).—Sides of valves undulate; angle acute and slightly produced; centre tumid; granules in lines, radiating from the centre, scarcely discernible; pseudo-nodule apparent. = *T. striolatum*?, SBD. i. p. 27, pl. 5. f. 46; *T. undulatum*, Bri. *l. c.*; West, TMS. viii. p. 148, pl. 7. f. 5. This species in its living state forms short filaments united in a distant series.

T. *striolatum* (E.). — Sides convex, slightly undulated; angles attenuated, ending in minute papillæ. KB. t. 18. f. 10. = *T. membranaceum*, Br MJ. i. pl. 4. f. 15. Thames mud, Cuxhaven. Walls of the frustule extremely delicate, dotted over with very minute cellules.

T. *Parmula* (Br.). — Sides gibbous, with produced mammiform angles; surface minutely punctated. Br MJ. iv. p. 275, pl. 17. f. 2. Natal. Var. β with 4 angles. West, TMS. viii. p. 147, pl. 7. f. 1. Frustules minute, in outline resembling a shield.

T. *Americana*.—Sides convex, slightly undulated; angles rounded; cellules minute. = *T. Amblyoceros*?, Br MJ. i. p. 250, pl. 4. f. 14. Fossil. Richmond, Virginia. The rounded angles without appendages distinguish this species from the others in this section.

T. *margaritaceum* (Ralfs, n. s.). — Valves with rounded angles, and straight or slightly convex sides; surface with conspicuous pearly granules, which are scattered at a triradiate central space, and arranged in radiating lines at the margin. Barbadoes deposit. Johnson. The valve is bordered by a row of larger granules; and only a narrow inconspicuous terminal portion of the angles appears smooth.

T. *gibbosum* (Harv. & Bail.).—"Almost inflato-globose, the sides very convex, angles prominent; surface marked as in *T. concavum*." Small. Proc. of Acad. of Nat. Sci. Philadelphia, 1853. Tahiti.

5* *Frustules not spinous, sulcate, veined, nor undulate.*

† Cellules large, hexagonal.

T. *Favus* (E.). — Sides straight or slightly convex; angles obtuse, with horn-like processes; surface reticulated with large hexagonal cellules. (xi. 43, 44.) = *T. megastomum*, Br MJ. i. pl. 4. f. 7?; *T. fimbriatum*, Wallich MJ. vi. p. 247, pl. 12. f. 4–9. Recent and fossil, not uncommon. Diam. 1-200" to 1-150". Front view with the central portion minutely punctated, the lateral portions scarcely constricted beneath the short stout processes. Mr. Brightwell figures a quadrilateral form of this species with concave sides.

T. *serratum* (Wallich).—Valves (quadrilateral) furnished with a horn-like process at each angle, and from 4 to 6 elongated scattered spines, with furcate apices; sides or plates of connecting zone joined by dovetailed margins. Wallich, MJ. vi. p. 243. pl. 12. f. 1–3. St. Helena. Connecting zone as well as valves marked with a delicate but well-defined hexagonal areolation. This species is remarkable chiefly for the peculiar structure of its connecting zone, the plates having their communicating margins serrated so as to fit into each other.

T. *grande* (Br.). — Sides convex; angles attenuated, obtuse; hexagonal cellules numerous. Diam. 1-100″. Br MJ. i. p. 249, pl. 4. f. 8. *T. orientale*, Harv. & Bail. *l. c.* Indian Seas, Mindanao. "The largest and stoutest species of this genus" (Br.). The descriptions do not suffice to distinguish this species from large specimens of *T. Favus*.

T. *muricatum* (Br.).—Sides straight; angles ending in a stout horn-like process; cellules large, hexagonal. Br MJ. i. p. 249, pl. 4. f. 5. From the cleanings of shells. A minute species, distinguished by its pointed angles. Front view nearly square, with the central portion smooth, and the lateral ones turgid between the prominent processes.

T. *ocellatum* (E.).—Sides slightly concave; angles attenuated, obtuse; cellules unequal, large, hexagonal in the centre, gradually becoming smaller at the sides, in no distinct order. KSA. p. 141. Mouth of River Tenasserim, India.

2† Lateral surfaces with three pseudo-nuclei, not situated at the angles.

T. *sculptum* (Sh.). — Sides straight; angles prolonged into conical points; granules scattered; surface with three circular pseudo-nuclei, one opposite the middle of each side. Sh MT. ii. pl. 1. f. 4. Natal. In form this species somewhat resembles *T. acutum*; but its pseudo-nuclei are eminently characteristic.

3† Frustules triradiate, with very concave sides.

T. *Solenoceros* (E.).—Triradiate, with deeply concave sides; angles prolonged into long, linear, obtuse arms; cellules radiating. Br MJ. i. p. 248, pl. 4. f. 1. Bermuda earth. (VI. 15.) This species differs from every other by its long linear rays, which have neither pseudo-nodules nor processes.

T. *Pileus* (E.).—Somewhat triradiate, with very concave sides; angles tapering, obtuse, with pseudo-nodules; cellules minute, radiating. EM. pl. 19. f. 18.=*T. brachiolatum*, Br MJ. i. pl. 4. f. 2. Fossil, Greece; recent, New Zealand. Mr. Brightwell refers his *T. brachiolatum* to the next species.

T. *Pileolus* (E.). — Somewhat triradiate, with very concave sides; angles produced, obtuse, with pseudo-nodules; cellules small, scattered. EM. pl. 35 A. 21. f. 17. = *T. obtusum*, Br MJ. iv. p. 251, pl. 4. f. 20. Antarctic Ocean. Resembles *T. Pileus* in form, but is smaller, and its cellules are scattered.

4† Frustules not triradiate; angles with pseudo-nodules, or minutely punctated.

T. *concavum* (Harv. & Bail.).—Sides very concave; angles rounded, minutely punctated; cellules of centre arranged in simple and forked radiating lines. H. & B., Trans. of Acad. of Philadelphia, 1853. Tahiti.

T. *Wallichii* (Ralfs). — Valves with minute radiate areolation, a row of marginal puncta, and a minute horn-like process at each angle.=*T. punctatum*, Wallich, TMS. viii. p. 48, pl. 2. f. 21. India, Atlantic.

T. *arcticum* (Bri.). — Valves with slightly convex or straight sides; areolations small, but distinct, radiating in lines from the centre, and becoming minute at the angles, which are rounded and slightly inflated.=*T. Wilkesii*, var. *β*, with 4 angles; *Amphitetras Wilkesii*, Bri MJ. i. p. 250, pl. 4. f. 11; Ro TMS. viii. p. 58. Beechey Island, Arctic Regions; Puget's Sound, Vancouver's Island; and Montery stone. The specimens obtained from Vancouver's Island have proved that Triceratium has been erroneously considered a free form, and that its proper position is with Amphitetras and Biddulphia; the specimens alluded to show it attached to Zoophytes, and the frustules connected at the angles by a short stipes or cushion, exactly like Amphitetras.

T. *Montereyii* (Br.).—Sides concave; angles rounded, with pseudo-nodules; cellules minute, largest in the centre, which is much inflated. Br MJ. i. p. 251, pl. 4. f. 8. Fossil. Monterey Bay. This species is easily distinguished from *T. arcticum* by its central boss and larger cellules.

T. *punctatum* (Br.). — Sides straight; cellules large, puncta-like, scattered, smaller at the rounded angles. Br MJ. iv. p. 275, pl. 17. f. 18. Arctic Regions. (VI. 20.)

5† Angles without pseudo-nodules.

T. *formosum* (Br.). — Sides slightly concave; angles obtuse, without pseudo-nodules; cellules very minute, somewhat radiating. Br MJ. i. p. 250, pl. 4. f. 10. Shell cleanings from *Hippopus maculatus*.

Mr. Brightwell finds this species varying, with four and five angles. The front view is quadrate, not constricted, the angles produced into conical processes, between which the margin is nearly straight.

T. *condecorum* (E.).—Sides straight or slightly convex, with obtuse angles; cellules very minute, diverging in curved series. Br MJ. i. p. 250, pl. 4. f. 12. Fossil. Bermuda.

T. *obtusum* (E.).—Sides very convex; angles rounded, without pseudo-nodules; cellules circular, scattered. EM. pl. 18. f. 48, 49. Virginia.

T. *Amblyoceros* (E.).—Sides concave; angles broadly rounded, without pseudo-nodules; cellules minute, somewhat radiating. EM. pl. 18. f. 51. Virginia. This species has more rounded angles and smaller cellules than *T. obtusum*.

T. *Reticulum* (E.).—Sides straight; angles subacute, without pseudo-nodules; cellules minute, numerous. EM. pl. 18. f. 50. Fossil, America; recent from shell-cleanings. Front view with a narrow, smooth central zone; lateral surfaces not constricted beneath the slightly prominent angles.

T. *acutum* (E.).—Sides nearly straight; angles elongated into points; cellules not radiating. Br MJ. i. p. 251, pl. 4. f. 16. Bermuda. *T. acutum* is somewhat triradiate from its acuminated angles.

Doubtful or insufficiently known Species.

T. *scitulum* (Br.).—"A small species, but varying in size. On some of the frustules I have reckoned, on an end view, about 45 cells only; sides very slightly convex; angles open. Diam. 1-350"." Br MJ. i. p. 250, pl. 4. f. 9. Indian Ocean. Varies with four sides. Except in its smaller size, we see not how this species differs from *T. Favus*.

T. *Africanum* (E.). — Sides convex; angles rounded; cellules large, in radiating series. EM. pl. 35 B. 19. f. 1. Recent. West Africa. In form resembles *T. obtusum*.

T. *comptum* (E.).—Sides straight, and having a marginal fringe; angles prolonged into short, stout spines; cellules large, hexagonal. Ro MJ. ii. p. 283, f. 2. England. "The cellular markings are as large as in *T. Favus*, and I am rather doubtful whether it may not be a young form of that species; but the length of the processes, and fringe-like row of cells at the margin, appear to give it a distinctive character" (Roper).

T. *crassum* (Sh.). — "Much smaller than *T. contortum*. Is characterized by the reticulations being coarse and irregular in form, and the horns very large as compared with the size of the valve." Sh. in TMS. ii. p. 15. Natal.

T. *hyalinum* (Br.). — "Small, transparent, surface with very minute dots or cellules; sides regular and straight." Br MJ. iv. p. 275, pl. 17. f. 16. Barbadoes. = *T. Reticulum*.

T. *arcuatum*. — Sh TMS. ii. pl. 1. f. 5. Natal. The figure resembles that of *T. Pileus*, but without pseudo-nodules. It is probably, however, the same.

T. *exiguum* (Sm.).—Triradiate; angles elongated into linear truncated processes; cellules very minute, scattered. SD. ii. p. 87; Br MJ. iv. p. 274, pl. 17. f. 1. Fresh water. Ormsby, Norfolk. (VI. 14.)

T. *Pentacrinus* (Wallich). — Valves slightly convex, with 5 angles, with a short horn at each angle. Surface spinous, divided into compartments by anastomosing lines or costæ, which radiate irregularly from the centre. Var. β with 4 angles, γ with 6 angles. Wallich, MJ. vi. p. 251, pl. 12. f. 10-14. St. Helena. We scarcely see how this form differs from *Amphitetras ornata* of Shadbolt.

T. *dubium* (Br.). — Valve minute, clypeate, with 6 angles, the lower one much produced; surface of valve coarsely punctate. Br MJ. vii. p. 180, pl. 9. f. 12. Mauritius, Californian guano, India. "We place this form (which is not of unfrequent occurrence) provisionally among the Triceratia. It probably forms the type of a new genus" (Br. *l. c.*).

T. *Malleus*, Br MJ. vi. p. 164, pl. 8. f. 6. Not Diatomaceous?

Genus AMPHITETRAS (Ehr.). — Frustules cellulose, cubiform, cohering into a zigzag attached filament; in lateral view quadrangular, with a pseudo-opening at each angle. Since Mr. Brightwell's discovery of quadrangular states of Triceratium, the only remaining distinction between that genus and the present is, that in this the frustules form catenate attached filaments; but, according to Professor Bailey (as already noticed), even this character is not confined to Amphitetras. Professor Smith, indeed, remarks, "The projection of the connecting membrane beyond the suture of the valve is a circumstance which meets us for the first time in Amphitetras;" but we believe that this occurs in every genus in which the new portions of the dividing frustules are formed within the persistent central portion, and in this respect there is no perceptible difference between Triceratium and Amphitetras. As some species have been placed in Amphitetras solely on account of their quadrate form, the correctness of their position is consequently not free from doubt.

AMPHITETRAS *antediluviana* (E.).—Lateral view with straight or concave margins; angles rounded, each with an apparent opening; cellules large, radiating, and concentric. Living, Denmark, England, America, &c.; fossil, Oran, Greece. (XI. 21, 22.) *A. tessellata*, Sh TMS. ii. β, sides very concave; the cellules on the central portion are smaller, and arranged in longitudinal lines.

A. *Adriatica* (K.).—"Lateral view quadrate; cellules radiating and concentric; primary sides plane." KSA. p. 134. Adriatic Sea.

A. *parallela* (E.).—Cellules in lateral view large, arranged in parallel lines. Fossil. Greece.

A. *crucifera* (Kitton, n. sp.).—Valves punctate, and marked by a line passing from the centre to each angle. Front view deeply constricted on either side of connecting zone. Valves minute, with slightly convex sides, and produced mammiform angles. Cleanings of shells from West Indies. Distinguished by the cruciform lines of the valve, which taper from the centre to the angles, where they terminate in points. We have seen 4 or 5 frustules connected by the angles.

Doubtful or imperfectly known Species.

A. *ornata* (Sh.).—"Size small, margins concave, and folded so that each valve is not unlike in form to a collegian's cap; surface somewhat irregularly ornamented with delicate vein-like markings." TMS. ii. p. 16, pl. 1. f. 10. Natal. Var. β, with 5 angles. (VIII. 16.) This is probably a state of some veined species of Triceratium.

A. *favosa* (Harv. & Bail.).—"Sides scarcely concave; lateral view quadrangular; angles almost straight, scarcely produced; surface tessellated with large hexagonal cellules." Proc. of Acad. of Philadelphia, 1853. Mindanao.

A. *Crux* (Bri.).—Valves cruciform, with the angles widely rounded; surface coarsely punctate. Cleanings from shells, West Indies; Californian guano. Bri JMS. vii. p. 181, pl. 9. f. 13. This may be a 4-angled var. of *Triceratium castellatum* or *T. trisulcum*.

Genus AMPHIPENTAS (Ehr.).—Frustules free, simple, cellulose or granulate, pentagonal. Probably pentagonal forms of Triceratium.

AMPHIPENTAS *alternans* (E.).—Sides concave; angles obtuse; the angles of the external pentagon alternating with those of a smaller central one, which has a circular umbo at its middle. KA. p. 134; EA. p. 122, pl. 2. 6. f. 9. Cuba. (XI. 32.)

A. *Pentacrinus* (E.).—Pentagonal; its dorsal surface presenting a striated ring. Diam. 1-240″. KA. p. 134. Fossil. Greece. Fragments like Amphitetras.

A. *flexuosa* (B. MS.).—Sides four or five, gibbous; angles conical; surface flat; cellules hexagonal, covered by minute puncta. Gulf-stream. (VI. 22.) From drawings by Professor Bailey. "Under a low-power, the markings appear circular, as represented in the figures" (B.). The margins are undulated in consequence of their gibbous projections, as in *Triceratium Parmula*, and may be 4- and 5-angled forms of that species.

FAMILY XII.—TERPSINOËÆ.

Frustules quadrangular, smooth, compressed, furnished with unequal transverse costæ or incomplete septa interrupted at the middle. We have separated this small group from Striatelleæ because, notwithstanding the great external resemblance of their solitary frustules, we believe them to differ essentially in structure. In Striatelleæ the septa are longitudinal, and divide the central portion into chambers. In Terpsinoëæ they are transverse and confined to the lateral portions, which appear in the front view as in Biddulphieæ. The relation of Terpsinoëæ to the latter was pointed out by Meneghini. The smooth frustules and straight lateral margins without processes distinguish the Terpsinoëæ.

Genus ANAULUS (Ehr.).—Frustules simple, subquadrate, smooth; septa lateral, unequal, not thickened at their extremities; lateral view oblong. Anaulus resembles Biddulphia, but its costæ or septa are unequal, and it has no tubular processes. A genus of Mollusks has been also, but more recently, called Anaulus.

ANAULUS *scalaris* (E.). — Turgid in the young state; but when full-grown very wide and much flattened, having 4, 6, 8, or 14 lateral constrictions; laterally oblong with transverse bars, giving it a ladder-like appearance. EM. pl. 35 A. 22. f. 1, 2. Antarctic Sea. Diam. 1-480″ to 1-180″. The lateral valves, in the front view, have undulated margins, caused by the constrictions. (VIII. 37.)

A. *Campylodiscus* (E.). — Quadrangular; each valve very much compressed, triangular, with obtuse angles, and having laterally two slight constrictions. Bermuda. Diam. 1-372″. It has the habit of an unequal-sided Triceratium or of a Campylodiscus.

Genus TERPSINOË (Ehr.).—Frustules concatenate; costæ unequal, capitate, curved so as to resemble musical notes. "If we imagine a series of frustules of Tabellaria joined together, not laterally, but the head of one to that of another, or in the direction of breadth instead of length, we shall form the most just idea of this genus" (Ehr.). The capitate costæ, which in their form so greatly resemble musical notes, distinguish Terpsinoë from every other genus.

We unite Tetragramma with Terpsinoë, as Professor Bailey finds the "music-like notes" vary in number from two to at least eight on a side, and does not consider their number even specifically important.

TERPSINOË *musica* (E.). — Frustules finely punctated, with two or three transverse bands, the lateral valves having costæ in each division; lateral view oblong, showing two or three inflations and narrower rounded ends. EA. pl. 3. 4. f. 1; Rab D. t. 10. America, Africa. (XI. 47.) Frustules with finely punctated lateral portions, between which the central zone (having two puncta at each end) appears like a band. Two or three bars cross lateral and central portions from one lateral margin to the other, and divide them obscurely into compartments. The lateral view has the margins sinuated, from constrictions corresponding with the transverse bands.

T. *Americana* (Bailey). — Frustules quadrangular, resembling those of *T. musica*, but smaller, more minutely punctate, with two transverse bars and two costæ in each lateral valve. = *Tetragramma Americana*, Bail. Smithsonian Contr. 1853, p. 7. f. 1. As in *T. musica*, the costæ resemble notes of music, but are confined to the central compartments of the valves. In the lateral view it resembles the preceding species, but has fewer cross-bars.

T. *Indica* (E., Kütz.). — Frustules subquadrate (catenated?), compressed, two or four times constricted; lateral valves densely granulate, central portion smooth, with two puncta at each end; median costæ dilated at the end. KSA. p. 119. = *Anaulus Indicus*, E. India, frequent.

T. *Javanensis* (EM. pl. 34. 8. f. 16). — The figure resembles *T. musica*; but the central portion is marked by longitudinal lines, which converge at each end.

Species known to us only by name.

T. *Asiatica*, Asia. = *Tetragramma Asiatica*, E.

T. *Japonica* (E.), Japan.

T. *Australis* (E.), Sandwich Islands.

T. *Libyca* = *Tetragramma Libycum*, Africa.

T. *Brasiliensis* (E.).—Music-like marks very small. According to Ehrenberg, it approaches *T. musica* in form. Brazil.

Genus PLEURODESMIUM (Kütz.). — Frustules compressed, connected in fascia-like filaments by short thread-like processes; lateral portions punctated and furnished with music-like marks, the hyaline central smoother portion forming a band between them.

Although Pleurodesmium was placed by Professor Kützing in a different family from Terpsinoë, yet these genera appeared to us so closely allied that we found it difficult to distinguish them,—a difficulty experienced also by Mr. Tuffen West on examining an authentic specimen of Pleurodesmium given us by our valued friend M. de Brébisson, which, however, was unfortunately not in a condition to afford a satisfactory examination.

The frustules, as in Terpsinoë, agree with the Biddulphieæ in having the lateral valves largely developed and entering into the front view; they are furnished with costæ, enlarged at the ends and resembling notes of music. M. de Brébisson thinks this genus very distinct, the frustules being connected in straight series by thread-like points of attachment proceeding from the furrows; but these he informs us are very short indeed, for which reason Kützing, like ourselves, seems to have overlooked them.

Pleurodesmium *Brébissonii* (Kütz.). —Frustules contracted at their junction; costæ rugose. KSA. p. 115. Cayenne. (vi. 23.) Lateral view oval, having transverse bars and undulated sides.

Genus EUNOTOGRAMMA (Weisse).—Front view as in Anaulus; lateral view lunate, with undulated dorsal and ventral margins. Dr. Weisse observes that in the front view Eunotogramma resembles Gomphogramma, and in the lateral one Eunotia (Epithemia?). In both instances, however, the resemblance is evidently very superficial, and does not require the distinctions to be pointed out. The genus doubtless belongs to the Terpsinoëæ, and seems to differ from Anaulus only in the lunate form of the side view.

Eunotogramma *tri- quinque- septem- et novemloculata* (Weisse).—Lateral view divided by two, four, six, or eight transverse septa into three, five, seven, or nine loculi. Weisse, Bulletin de l'Acad. de St. Pétersbourg, xiii. p. 278, t. 3. f. 37. Fossil. Russia. Front view with a narrow connecting zone, and lateral, equal, stout, pinna-like septa. Lateral view semilanceolate, constricted at each septum, and therefore having as many undulations, as loculi; ends rounded. (viii. 30.)

FAMILY XIII.—CHÆTOCEREÆ.

Frustules smooth or faintly punctated, simple or united into awned filaments; lateral valves, in the nonfilamentous forms, usually unequal, inflated, lobed, and often furnished with bristles or other appendages; lateral view oval or circular. Marine, mostly fossil. Until Mr. Brightwell pointed out their true affinity, the genera included in this group were distributed amongst three families. Between Syndendrium and the Anguliferæ we can perceive no resemblance; but the connexion of Chætoceros with the Biddulphieæ, and the other genera with the Melosireæ, is far more plausible. In Stephanopyxis, a true member of the latter family, the valves are crowned with bristles or spines, as in some Chætocereæ. In Melosireæ, however, all the members ought to be cylindrical, whereas in this family the shape, in the lateral view, is much oftener oval than circular. Although it is not difficult to point out differences between the Chætocereæ and other groups, yet, on account of the variety in their forms, we confess our inability, in the present state of our knowledge, to give a concise definition which shall include its own members and exclude all others. We shall therefore content ourselves with pointing out those characters which will enable us to recognize with tolerable certainty those Diatoms which belong to it. The filamentous species differ by their awns so much from every other genus that they cannot be mistaken. Mr. Brightwell, in his excellent paper on Chætoceros, regards this as the typal state: he says, "A careful examination of most of the species of Chætoceros and other allied genera, described by Ehrenberg as found in a fossil state, have satisfied us that most, if not all these, will, when found in a living state, turn out to belong to the singular filamentous and horned group which may for the present be comprehended in the genus Chætoceros." Those forms also which have dissimilar-shaped valves, especially when lobed or hirsute, may be safely placed here; and it is very probable that some species with unequal valves, still retained in Melosireæ, might likewise be included with propriety.

The genera themselves are by no means firmly established; for, as Mr. Brightwell observes, "most of the described species have been found only in a fossil, or rather, if we may so term it, a deposit state; and in this state it is clearly difficult to form a correct idea of either species or genera, since deposits give no information as to the Diatoms being in threads or solitary frustules." We shall not attempt to reconstruct the genera, for to do so prematurely would only increase the difficulty and cause confusion; for "much must yet be brought to light before a satisfactory classification of this group can be effected" (Brightwell). Although only a few species have as yet been gathered in a living state, yet, as most of them are found in guano, it is probable that nearly all still exist; and when their habits are better known, we may fairly expect to obtain them. They seem to inhabit deep water, as Mr. Norman has met with them, more than once, in the stomachs of Ascidiæ from such situations.

Genus CHÆTOCEROS (Ehr.).—Frustules without striæ, united with the adjacent ones by the interlacing on each side of awns proceeding from the frustule or from a cingulum between the frustules, and so forming a filament. The filaments are imperfectly silicious and very fragile. The awns are tubular, sometimes spinous or serrated, and often of great length, though, according to Kützing, short in an early state. Kützing defines the genus as follows:—"Frustules concatenated, equally bivalved, turgid, with two apertures on each side, which at the earliest period are very shortly tubular and the corpuscles contiguous, afterwards longly awned and the corpuscles distant." If the awns be overlooked or broken off, the frustules may be mistaken for species of Melosira. No person who wishes to study this beautiful but difficult genus should fail to obtain Mr. Brightwell's valuable paper on it in the Journal of Microscopic Science.

* *Frustules, in lateral view, constricted at the middle.*

CHÆTOCEROS *Diploneis* (E.).—Frustules in lateral view panduriform, in front view linear; awns smooth. KSA. p. 138; EM. pl. 33. 18. f. 1; Bai. in Amer. Journ. of Science, xlviii. pl. 4. f. 19 (lateral view). = *C. Bacillaria*, Bai. *l. c.* f. 18 (front view). Bermuda deposit. "*Chætoceros Diploneis* and *C. Bacillaria* are merely different positions of the same species" (Bai. *in lit.*). In the front view the frustules are linear, three or four times as long as broad, with stout awns arising from the angles. Lateral view panduriform, with rounded ends.

2* *Frustules laterally oval or circular; awns spinous.*

C. *boreale* (Bail.).—Frustules quadrate; awns very long, spinous, arising from the inner surface, not from the angles. BC. 1854, pl. 7. f. 22, 23; Bri JMS. iv.

p. 107, pl. 7. f. 12–15; Wallich, TMS. viii. p. 48, pl. 2. f. 18; West, TMS. viii. p. 152, pl. 7. f. 13. St. George's Bank, Atlantic Ocean. (vi. 25.) "This species was found in considerable numbers in the contents of the stomach of the *Botryodactyla grandis*." Awns 30 to 50 times longer than the body.

C. *Peruvianum* (Bri.).—Valves hemispherical, with two very stout, long, recurved, spinous awns proceeding from the centre of the rounded ends. Br JMS. iv. p. 107, f. 16–18. In Peruvian guano. A remarkable and very distinct species, characterized by the rounded apex of the valve. Lateral view circular?

3* *Frustules laterally oval or circular; awns smooth.*

C. *Tetrachæta* (E.). — Frustules with four, very long, filiform, smooth awns on each side. KSA. p. 138. Antarctic Sea. Diam. without the awns, 1-1152″.

C. *Dichæta* (E.).—Frustules with two, very long, filiform, smooth, often flexuose awns on each side. KSA. p. 138. Antarctic Sea. Diam. without the awns, 1-1152″ to 1-720″. The description is too imperfect to enable us to distinguish the species from some of the following ones.

C. *confervoides* (n. sp.). — Frustules large, quadrate; awns stout, smooth, arising a little beneath the rounded angles; lateral view circular. Mount's Bay (stomach of Ascidiæ), Cornwall. We have seen only one concatenated specimen; it formed a short, very fragile, conferva-like filament of about 12 joints, which were equal in length and breadth and in close apposition. Internal colouring matter brownish, and collapsed into a roundish spot in the centre of each frustule.

C. *Wighamii* (Bri.).—"Frustules cup-shaped, with a band round the mouth of the cup, and a neck or bulb proceeding from the centre; beset with minute short spines or papillæ in all parts except the band; lateral view oval; awns elongated, smooth." Br MJ. iv. p. 108, pl. 7. f. 19-36. In brackish water, near Breydon, Great Yarmouth. "Boiled in acid, the filaments break up, and the frustules in an isolated state, and detached rings with the horns proceeding from them, are all that can be detected. The rings may readily be distinguished from the frustules seen endwise, as they are open and without dots, while the frustules seen endwise are dotted" (Bri.). We have seen no perfect specimen of this interesting species; but as Mr. Brightwell's fig. 12 shows two joints similar to other species of this genus, we are inclined to regard the Goniothecia-like bodies as internal cells, of the same nature as the internal cells of Himantidium, Meridion, &c., which we believe to be sporangia; but whatever their true character may be, we have scarcely a doubt that Mr. Brightwell is right in supposing *Goniothecium crenatum*, *G. hispidum*, *G. Navicula*, and *G. barbatum* to be allied forms belonging to the same genus as this species. (vi. 24.)

C. *incurvum* (Bail.). — Frustules in front view linear, with smooth, filiform, recurved awns arising from the angles; lateral view oval. Bri. *l. c.* pl. 7. f. 9–11. Fossil. Virginia, Peruvian guano. In stomach of Ascidiæ, Penzance. Easily known by its small size and slender recurved awns.

C. *furcillatum* (Bail.).—Awns of adjoining frustules closely approximate below, then diverging and becoming nearly parallel; lateral view oval. Bai. on Microsc. Forms in the Sea of Kamtschatka, p. 3, pl. 1. f. 4. Common in the Sea of Kamtschatka. The minutest species in the genus.

C. *didymus* (E.). — Frustules longer than broad, gibbous or angular on the outer margin, and usually slightly so on the inner margin also; awns smooth, filiform, arising from the angles. Bri. *l. c.* pl. 7. f. 3–7; KSA. p. 138; EM. t. 35 A. 18. f. 4. Common in Peruvian guano. Stomach of Ascidiæ, Penzance. A variable species, distinguished by its angular or gibbous margins; lateral view oval. Ehrenberg's two figures in the 'Microgeologie' differ from each other, as well as from any specimens we have seen. Greatest diameter 1-1080″.

C. *Gastridium* (E., Bri.).—Frustules binate, smooth, transversely oblong, truncated at each end, abruptly dilated at the middle of the ventral surface, not contiguous, Bri. *l. c.* pl. 7. f. 8. = *Goniothecium Gastridium*, EM. pl. 18. f. 91. Virginian guano. Ehrenberg describes and figures it with an external umbo (gibbous), thus approaching to *C. didymus*.

C. *armatum* (West).—Frustules quadrangular, forming a compressed filament; angles excavated; from each angle arises a long, obtuse, curved seta, with several acute ones at the base. West, TMS. viii. p. 151, pl. 7. f. 12. Abundant on various parts of the coast of England.

This species, in its living state, is invested with a mucous covering, and is scarcely, if at all, silicious,—a circumstance which has caused many doubts as to its diatomaceous nature.

Genus ATTHEYA (West).—Frustules compressed, annulate; annuli indefinite; valve elliptical-lanceolate, with a median line; angles spinous. The true position of this genus is doubtful; but, from examination, it appears to approach nearer to Chætoceros than to any other genus excepting Striatella, from which, however, it is easily distinguished by the spinous angles and absence of stipes.

ATTHEYA *decora* (West).—Annuli 12 to 28; septa alternate; valve with median line and central nodule. West, TMS. viii. p. 152, pl. 7. f. 15. Cresswell Sands, Druridge Bay. (VIII. 35.)

Genus BACTERIASTRUM (Shadbolt).—Frustules awned, united into a jointed, conferva-like, cylindrical filament; valves discoidal, with marginal radiating awns. Bacteriastrum agrees with Chætoceros in its filamentous character and in the presence of awns, but differs from it in having the awns of its discoidal valves marginal and radiant. Marine. Stomachs of marine animals, &c.

BACTERIASTRUM *furcatum* (Sh.). — Awns smooth, much elongated, forked. =*Actiniscus sexfurcatus*, ERBA. 1854, p. 237; EM. pl. 35 B. 4. f. 15; *A. biseptenarius*, E.; *A. bisoctonarius*, E. Atlantic. The awns vary in number and in the length of the forked portions. (VI. 26.)

B. *curvatum* (Sh.). — Awns simple, elongated, smooth, symmetrically curved in one direction.

B. *Wallichii* (Ralfs).—Valves more or less cup-shaped, with 4 to 12 smooth, simple, divergent awns. = *Chætoceros Bacteriastrum*, Wallich, TMS. viii. p. 48, pl. 2. f. 16, 17. Atlantic. From Salpæ. Size extremely variable. (VI. 27.)

B. *nodulosum* (Sh.). — Awns simple, straight, rough.—Awns covered with small protuberances, like a knobbed stick.

Genus DICLADIA (Ehr.).—Frustules simple, one-celled, bivalved; valves unequal, turgid, one mostly simple and unarmed, the other two-horned; horns sometimes branched.

DICLADIA *Capreolus* (E.).—One valve with two styles arising from conical bases, and usually branched at the end. EM. pl. 35 A. 17. f. 8; Bri JMS. iv. pl. 7. f. 53–60. Virginia. Common in guano. The frustule consists of a narrow-linear central portion, projecting at each end, and two turgid lateral valves, which vary greatly in form. Usually the inferior one is smaller, simple, and unarmed, but is often bilobed. The larger valve is bilobed; the lobes mammiform or conical, each terminating in a style divided at its apex; occasionally, however, specimens have the upper valve unarmed or simple.

D. *antennata* (E.). — One valve, with two simple, setaceous, parallel, acute spines, articulated at the base, like antennæ; the other valve unknown. EM. pl. 35 A. 21. f. 9; KSA. p. 24. Antarctic Sea. This and the next species were constituted from single fragments.

D. *bulbosa* (E.).—One valve with two spines, which are divergent at the base, connivent above, bulbose and slightly sulcate in the middle part; the other valve unknown. EM. pl. 35 A. 21. f. 10; KSA. p. 24. Antarctic Sea.

D. *clathrata* (E.). — Frustule with a rounded, smooth, latticed body, and two unequal frontal horns. EM. pl. 18. f. 100; KSA. p. 25. Fossil. Virginia.

D. *Capra* (E.).—Smooth; one valve with two simple spines, the other unidentate or imperfectly sub-bidentate in the middle; central portion narrow-linear. EM. pl. 18. f. 99. = *Periptera Capra*, KSA. p. 26. Fossil. Virginia.

D. *Cervus* (E.). — Smooth, large; frontal horns long, branched. = *Periptera Cervus*, KSA. p. 26. Fossil. Maryland.

D. *Mitra* (Bai.).—Valve having two conical horns coalescing below into a conical base, and bearing branched processes above. B. in Silliman's Amer. Journ. July 1856, pl. 1. f. 6. Sea of Kamtschatka. Perhaps a state of *D. Capreolus*.

Genus GONIOTHECIUM (E.).—Frustules simple, having a central constriction or furrow; each end abruptly attenuate and truncate, so as to assume an angular figure. Fossil. Like other genera in this family, this is an unsatisfactory genus. The frustules are described as cylindrical; but we believe that most, if not all of them, are oval when viewed laterally. Mr. Brightwell makes the following remarks on eight of Ehrenberg's species:—"The two largest and most common are *G. Rogersii* and *G. Odontella*; and we think it probable these will turn out, if discovered in a recent or living state, to be Chætoceri. Of the remaining six species, we are led to conclude, from the discovery of the Breydon species, that two of them belong to the genus Chætoceros, and are, when living, filamentous. They are *G. Gastridium*, of which we have found many specimens with the horns perfect, and *G. crenatum*. A figure of a frustule of this species is given in the 'Microgeologie' of Ehrenberg, and it can scarcely be distinguished from the frustules of the Breydon species. *G. hispidum* and *G. didymum* scarcely appear to differ from some of the smaller frustules of the Breydon species. *G. Navicula* and *G. barbatum* are clearly allied to *G. crenatum*, or our Breydon species." The species differ in form, and sometimes do not correspond with the generic character. *G. Gastridium* (E.) is proved by Mr. Brightwell's discovery of its awns to be a species of Chætoceros.

GONIOTHECIUM *Odontella* (E.). — Valves binate, smooth, conjoined by a central process, and by their connivent apices, so as to form on each side a large oblong aperture, constricted at its middle; margin undulate. EM. pl. 33. 15. f. 16; KSA. p. 23; Bri JMS. v. pl. 7. f. 47, 48. Virginia. Diam. 1-480″ to 1-276″. Distinguished by its large size and undulated margin, the central undulation forming an umbo; lateral view oval. (VI. 29.)

G. *Rogersii* (E.). — Valves binate, smooth, conjoined by a broad central process, often with connivent apices, forming suborbicular apertures; margin undulate. EM. pl. 18. f. 92, 93; KSA. p. 23. Virginia. Diam. 1-588″. Smaller than *G. Odontella*; "valves dorsally subquadrate, angular, with three whorls, laterally elliptic-oblong, with two or three median circles;" central undulation umbonate. Mr. Brightwell's figures are more irregular, and do not correspond so accurately with the definition.

G. *obtusum* (E.).—Valves smooth, inflated, with three rounded lobes; central or constricted portion forming a narrow band. EM. pl. 18. f. 95; KSA. p. 23. Virginia. Diam. 1-696″.

G. *monodon* (E.). — Valves binate, smooth, not contiguous, each linear-oblong, truncate at each end; outer side uniformly straight, the inner with a median tuberosity. EM. pl. 18. f. 97; KSA. p. 23. Virginia, California. Ehrenberg's figures represent a canoe-shaped valve, the outer margin convex, the inner with incurved ends and a central projection (connecting process), and agrees but badly with the specific character.

G. *hispidum* (E.). — Frustules semilunate, hispid, with an umbo at the centre of inner margin. EM. pl. 18. f. 107; KSA. p. 23. Virginia.

G. *Navicula* (E.). — Frustules small, smooth, with a linear produced central portion and a turgid or inflated valve on each side. EM. pl. 18. f. 105; KSA. p. 24. Virginia. In this species the central portion projects beyond the lateral valves, instead of being constricted.

G. *didymum* (E.). — Binate, smooth, transversely oblong, obtuse; one side emarginate at the centre, the other with two tubercles. EM. pl. 18. f. 104; KSA. p. 23. Virginia. Diam. 1-1200″. Ehrenberg's figure shows two unequal valves without any interstitial portion, each valve with two rounded lobes. It resembles a hornless state of Dicladia, except that it wants the central portion.

G. *barbatum*, EM. pl. 18. f. 106. Virginia. Ehrenberg's figure has a narrow-linear, longly produced central portion and two unequal turgid valves—the smaller smooth, the larger conic with a tuft of hairs at its apex.

G. *crenatum*, EM. pl. 39. 3. f. 74. Ehrenberg's figure is semilunate, with a neck-like truncated cone on its inner side. This species, except in being smooth, exactly resembles Mr. Brightwell's figures of the internal frustules of *Chætoceros Wighamii*, and doubtless belongs either to that or to an allied species of Chætoceros. (XV. 10.)

Genus OMPHALOTHECA (Ehr.).—Characters unknown to us. Judging from Ehrenberg's figure of the only species, it seems scarcely distinct from Goniothecium.

OMPHALOTHECA *hispida*, EM. pl. 35 A. 9. f. 4*. Ganges. The figure apparently represents a frustule in the process of division. The valves are unequal; the smaller one smooth, the larger somewhat conical and furnished with scattered spines; connecting-zone slightly produced beyond the valves. (VIII. 44.)

Genus PERIPTERA (Ehr.). — Frustules simple, compressed, unequally bivalved; valves simple, continuous, not cellulose; one valve naked, turgid, the other winged or horned; horns affixed to the extreme margin, sometimes branched. Approaches very near to Syndendrium and Dicladia. We think these three genera might be united with advantage.

PERIPTERA *tetracladia* (E.).—Smooth, almost navicular; one valve with four equidistant spines, branched at the apex, the other simple. EM. pl. 33. 18. f. 9. Fossil. Bermuda deposit. Diam. 1-1440″, including spines 1-864″. Without the spines, it resembles an Amphora. (VI. 30.)

P. *chlamidophora* (E.).—Smooth, almost navicular; one valve at the side plane and surmounted by a finely-nerved membrane, the other turgid at the middle, unarmed. EM. pl. 18. f. 96. Fossil. Bermuda. (VIII. 25.)

Genus RHIZOSOLENIA (Ehr.).— Filamentous; frustules subcylindrical, greatly elongated, silicious, annulate; annuli broadly cuneate; surface striated, extremities calyptriform, pointed with a bristle. This genus was constituted by Ehrenberg for the reception of certain silicious organisms found in guano and various fossil deposits. The characters assigned by him to this genus are, "lorica tubular, with one extremity round and closed, while the other is attenuate and multifid, as if terminating in little roots." The discovery of this remarkable genus in a living state has, we believe, proved that the species described by Ehrenberg are only fragments of forms similar to those we are about to describe. Professor Schultze has detected in *R. styliformis* and *R. calcar-avis* a circulation of minute granules analogous to the currents observed in the hairs on the filaments of *Tradescantia procumbens*. (Schultze, MJ. vii. p. 16.)

RHIZOSOLENIA *styliformis* (Bri.). — Frustules from 6 to 20 times as long as broad; transverse lines (annuli) distinct; surface striated, striæ oblique, about 40 in ·001″, terminal process at the base spatulate and bifid. Found in Noctilucæ, Yarmouth; stomachs of Ascidians, Yorkshire; Salpæ, Atlantic. Bri MJ. vi. p. 94, pl. 5. f. 5; Norman, ANH. xx. p. 158; Prof. Schultze, MJ. vii. p. 18, pl. 2. f. 1. (VII. 32.) From the elongated base of the calyptriform process a stout line or rib runs up on either side to nearly the apex of the cone; at base of the lines a small horn, slightly curved towards the annuli, is frequently to be detected. Self-division has been observed in this and some of the following species.

R. *imbricata* (Bri.). — Frustules 4 to 7 times as long as broad, annuli distinct, surface of valve coarsely punctate, terminal process subulate, entire. Found with the preceding species. Bri MJ. p. 94, pl. 5. f. 6. The direction of the transverse lines (annuli) and puncta give this species an imbricated appearance.

R. *setigera* (Bri.).—Frustules 5 to 15 times as long as broad, annuli obscure, striæ very faint, terminal bristle frequently as long as the colourless frustule. In Noctilucæ, Ascidians, and Salpæ. Bri. *l. c.* p. 96, pl. 5. f. 7. (VII. 33.) This species is remarkable for the great length of the terminal bristle and its extreme delicacy.

R. *alata* (Bri.).—Annuli distinct, striæ faint, terminal process alate, recurved, blunt. In Ascidians, Yorkshire. Bri. *l. c.* p. 95, pl. 5. f. 8. This curious little species is distinguished by its small but conspicuous setæ attached to the base of the calyptriform process.

R. *calcar-avis* (Schultze). — Frustules small, annuli indistinct; terminal process slightly sigmoid, the point resembling a bird's claw. Heligoland. Schultze, MJ. vii. p. 21, pl. 2. f. 5.

R. *robusta* (Norman, MS.).—Frustules very broad, slightly sigmoid, annuli narrow, calyptriform processes with lines radiating from the apices; bristles short, delicate, nearly linear. Striæ fine, about 55 in ·001″. Ascidians, North Sea, Teignmouth, Heligoland, Australia. (VIII. 42.)

Doubtful and insufficiently known Species.

R. *Calyptra* (E.). — Valve (terminal process) broadly conico-campanulate, smooth, its apex attenuated, acute. EM. pl. 35 A. 22. f. 17.; Bri. *l. c.* pl. 5. f. 2. Southern Ocean. (VII. 31.) This is probably the terminal process of *R. styliformis.*

R. *Campana* (E.).—Valve large; apex conic, longly attenuated, varies as if terminated by little roots; surface very finely granulated. KSA. p. 24. Bermuda deposit.

R. *ornithoglossa* (E.).—Valve tubular, conical, smooth, slender, with a much attenuated, acute apex, laterally resembling the tongue of a bird. EM. pl 33. 13. f. 21. Antarctic Sea.

R. *Americana.* — Frustules smooth, hyaline, tubular, interrupted by septa, one end round, the other styliform, simple or branched. EM. pl. 18. f. 98. Fossil. America. This seems a species very variable in size and form. The outline, however, of the rostrate valve bears some resemblance to a bottle, with the neck or beak simple or branched.

R. *hebetata* (Bai.). — Valve calyptriform, punctate, with a smooth, cylindrical base; apex expanded, compressed. B. in Silliman's Amer. Journ. July 1856, p. 5, pl. 1. f. 18, 19. Seas of Kamtschatka and Ochotsk. The expanded apex resembles in outline the flame of a candle. The punctate conical portions are most frequently seen; but specimens with the cylindrical base are occasionally found, Bail.

R. *Pileolus* (E.).—Valve small, short, as broad as long; central portion linear, produced; one valve resembling an umbo, the other conical, branched at apex. EM. pl. 18. f. 103. Virginia. Diam. 1-1320″. Has the habit of Dicladia or Goniothecium.

Genus SYRINGIDIUM (Ehr.).—Frustules simple, cylindrical; valves unequal, dissimilar, distended by a turgid middle ring. Maritime.

SYRINGIDIUM *bicorne* (E.).—Smooth, elongated, with three constrictions, one end pointed, the other subglobose, two-spined. EM. pl. 35 A. 9. f. 11*. Ganges. Africa. (VIII. 20.)

S. *Palæmon* (E.).—Resembles the preceding species, but is granulated. EM. pl. 34. 8. f. 15. Japan.

S. *Americanum* (Bai. MS.; VII. 34, from a drawing by Professor Bailey).—Common in Para River, and sparingly in the soundings off the mouth of the Amazon, South America. Frustules very minute, punctated; central portion quadrangular; valves unequal, one with a quadrate base, suddenly contracted and then tapering into a pyramidal spine terminated by a mucro; the other valve subglobose, with two short basal processes, each ending in a spine.

Genus SYNDENDRIUM (Ehr.).—Frustules simple, bivalved, subquadrangular, one-celled, without umbilicus in the middle; valves unequal, rather turgid, one smooth, the other furnished with many styles branched at the apex; margin naked. Syndendrium differs from Dicladia only in having several instead of two spines on one of its valves; yet Kützing has placed them in different families.

SYNDENDRIUM *Diadema* (E.).—Frustules lanceolate, with several spines in the centre of one valve, forked or penicillate (split up like a brush), their length equalling the thickness of the frustule. EM. pl. 35 A. 18. f. 13; Bri MJ. iv. p. 7. f. 49–52; Donkin, TMS. vi. p. 1. In Peruvian guano; Sea of Kamtschatka; stomach of Ascidia, Penzance. Diam. 1-1152″. The central portion is narrow linear, projecting at each end, the lateral valves convex, one smooth, the other with branched spines; lateral view oval.

Genus HERCOTHECA (Ehr.). — Frustule simple, turgid, of two unequal valves; membrane of valves continuous, not cellulose, generally veined beneath the free setæ, which are permanent and assume the place of an integument. Hence the corpuscles on the upper, contiguous margin of each valve appear as if crowned and enveloped (as it were, shielded) by the opposite setæ or membranes.

HERCOTHECA *mammillaris* (E.). — Valves smooth, with the centre of the base fringed round (fortified) with about twenty simple, opposite setæ, inserted on the margin itself, and extending beyond the mammillæ. EM. pl. 33. 18. f. 7. Fossil. Bermuda. (VII. 35.)

FAMILY XIV.—COCCONEIDEÆ.

Frustules elliptic, rarely bent, adnate by an inferior lateral surface, having a median longitudinal line and central nodule. "The lateral surfaces prevail so much that the central portion is reduced to a simple margin, and consequently it is difficult to obtain a front view" (Meneg.). Campylodiscus and Rhaphoneis, the only members of another family with which any of the Cocconeideæ are likely to be confounded, are distinguished by the absence of a central nodule. Those species of Navicula which are elliptic in the lateral view somewhat resemble species of Cocconeis; but they are never adnate, and in them the central nodule is equally developed in both valves.

Genus COCCONEIS (Ehr.). — Characters, those of the family. Frustules depressed or somewhat hemispherical; the central nodule is wanting or obscure in the inferior lateral surface, and sometimes there is a transverse as well as a longitudinal line. "The general form of Cocconeis is that of a disc of an ellipsoidal figure, with surfaces more or less exactly parallel, plane, or slightly curved. . . . The characters by which the species of this most elegant genus are distinguished one from another are still very slight" (Meneg.). The frustules in this genus are frequently furnished with an additional membranous covering, which also forms a border to them, and has been admitted into the specific definitions; but we believe this envelope generally, if not invariably, belongs to the immature state, and afterwards disappears more or less completely; and on this account we consider it an unsafe differential character. The descriptions apply to the lateral view, unless otherwise stated.

* *Disc smooth or with longitudinal lines.*

COCCONEIS *longa* (E.).—Very minute, linear-oblong, with rounded ends, smooth, except a median line and nodule. EM. pl. 5. 1. f. 25. Aquatic. Iceland.

C. *pumila* (K.).—Very minute, curved; lateral view oblong-elliptic, smooth, without lines or accessory border. KB. pl. 5. 9. f. 2. Aquatic. Europe. Length 1-1560″. Rabenhorst describes it as destitute of median line and nodule.

C. *pygmæa* (K.). — Very minute, smooth, elliptic, girt by a crenulate gelatinous border. KB. t. 5. 6. f. 4. Baltic Sea, on Ceramium. 1-2640″.

C. *molesta* (K.). — Minute, smooth, elliptic-oblong, without an accessory border, densely aggregated. KB. pl. 5. 7. f. 1, 2. Marine. Venice. 1-1800″ to 1-1680″.

C. *nidulans* (K.). — Elliptic-oblong, smooth; front view oblong, rectangular. KB. t. 4. f. 16. Coast of Normandy. 1-1320″. Nidulating in mucus.

C. *elongata* (E.). — Small, smooth, oblong-elliptic, plane. EM. pl. 5. 3. f. 26. America, Europe, Africa, China. Smaller than *C. Placentula*, but may be a variety of that species.

C. *Crux* (E.). — Smooth, elliptic, thin, with a transverse linear umbilicus. KSA. p. 53. Western Asia. Diam. 1632″.

C. *diaphana* (S.).—"Elliptical, scarcely silicious, diaphanous; striæ obscure. Length ·0012″ to ·0018″." SBD. i. p. 22, pl. 30. f. 254. "β, nodule dilated into a stauros." Sidmouth, Jersey.

C. *Pediculus* (E.). — Small, elliptic, somewhat angular, slightly curved; disc with very fine, dotted longitudinal lines. SBD. i. p. 21, pl. 3. f. 31. Aquatic. Common. β. *salina* (K.), narrower near the margin, furnished with very delicate transverse striæ: Saxony. γ. *minor* (K.). In this species the striæ are visible only when highly magnified. It is best distinguished by its slightly angular or rhomboid form—a character not noticed by Ehrenberg, who gives in the 'Microgeologie' only one figure, and five habitats. Diam. 1-2200" to 1-960".

C. *depressa* (K.).—Minute, much depressed, plane, elliptic, furnished near the margin with punctated striæ. KB. pl. 5. f. 8. 2. Aquatic. Europe. According to Rabenhorst, it resembles a small and flat state of the var. *salina* of the preceding species. Diam. 1-1800".

C. *Placentula* (E.). — Plane, elliptic, with faint, dotted longitudinal lines. SBD. i. p. 21, pl. 3. f. 32. (VII. 36.) Aquatic. Common. 1-1440". Ehrenberg, in his 'Microgeologie,' gives many figures and upwards of sixty habitats for this species. His definition differs from that of Professor Smith, and is as follows:—"Plane, elliptic, with an abrupt margin; within and without smooth." Having seen no authentic specimens of *C. Placentula* and *C. Pediculus*, we have adopted Professor Smith's views, but do not implicitly rely on them; for not only do Ehrenberg and Smith differ in their descriptions, but whilst the latter states that both species occur in the Lough Mourne deposit, the former has excluded them from his lists of species found in it.

C. *prætexta* (E.).—Small, elliptic, with six longitudinal lines on each side of the centre, and a dilated, smooth, areolar margin. EA. pl. 3. 3. f. 11. Japan, India, Africa, America.

C. *punctata* (E.).—Small, elliptic, with eight punctated longitudinal lines on each side of the median line. KB. p. 72, pl. 29. f. 30. Australia, America.

C. *euglypta*, EM. pl. 34. 6 A. f. 2. Florida. Ehrenberg's figure represents a small elliptic form, with broadly rounded ends, and a median line and nodule, having on each side parallel, distinctly dotted longitudinal lines.

C. *striolata* (Rab.). — Small, narrow-elliptic, with dense, faint longitudinal striæ on each side of the median line. Rab D. p. 28, pl. 10. f. 8. Aquatic. Salzburg.

C. *oblonga* (K.).—Oblong-elliptic, with somewhat acute apices and longitudinal lines. KB. p. 72, pl. 5. 8. f. 7. North Sea and Indian Ocean. 1-320".

C. *limbata* (E.).—Large, elliptic, with broadly rounded ends, very fine longitudinal lines, and a subentire gelatinous border. EM. pl. 14. f. 42. Adriatic and Mediterranean Seas. 1-576". Rabenhorst describes this species as like *C. Placentula* with a distinctly developed border-like membrane.

C. *oceanica* (E.). — Large, roundish-elliptic, with numerous delicately punctated, somewhat converging longitudinal lines; dorsum convex. KSA. p. 52. Europe, America. (XII. 42.)

C. *concentrica* (E.). — Large, broadly elliptic, with broadly rounded ends and concentric longitudinal lines. KB. p. 72, pl. 28. f. 15. Mexico.

C. *undulata* (E.). — Elliptic; dorsum slightly convex; exterior furrowed, with undulated concentric lines. KB. p. 72, pl. 5. f. 11. Baltic, Asia, Africa. 1-432". Not transversely striated.

C. *lineata*, EM. numerous figures and habitats. Australia, Asia, Africa, Europe. We have seen no description of this species; but, according to Ehrenberg's figures, it seems to differ from *C. undulata* in the nonconvergence of its longitudinal striæ. Apparently a very common species, as Ehrenberg gives upwards of fifty habitats.

C. *fasciata* (E.).—Large, elliptic; disc with dotted longitudinal lines on each side the median line, intersected by a transverse median smooth band. KB. p. 72, pl. 28. f. 14. Aquatic. Peru.

C. *gemmata*, EM. pl. 37. 2. f. 1. Oregon, Ægina. Ehrenberg's figure is large, broadly elliptic, with rounded ends and a smooth linear median line, having on each side five or six parallel, longitudinal, moniliform series of large granules.

C. *aggregata* (K.). — Oblong-elliptic, girt with a broadish lacerated, crenulate limb; disc having near the margin finely dotted rays, and in the middle punctated longitudinal lines. KB. p. 72, pl. 5. 8. f. 5. Baltic and North Seas. 1-1440".

C. *marginata* (K.). — Elliptic, with radiatingly punctated margin and discoid longitudinal lines. KB. p. 72, pl. 5. 6. f. 1. Marine. Europe. 1-840".

C. *dirupta* (Greg.). — Broadly elliptic or suborbicular, with a smooth median line, having on each side wavy longitudinal and faint transverse striæ. GDC. p. 19, pl. 1. f. 25. Scotland. The longitudinal striæ are most evident in the centre, and the transverse, which are somewhat radiant, near the margin. Under a low power the nodule appears dilated into a stauros. Professor Gregory states that it differs in its brown colour and conspicuous striæ from *C. diaphana*, the only allied species.

2* *Disc with radiant or transverse striæ.*

C. *striata* (E.). — Elliptic-oblong, of medium size, with parallel or somewhat converging transverse striæ. EM. many figures. Aquatic. Apparently common, as Ehrenberg gives upwards of forty habitats in different parts of the world. Lough Mourne deposit.

C. *borealis* (E.). — Elongated-elliptic or oblong with rounded ends and parallel or converging transverse striæ. EM. several figures. Ehrenberg gives about thirty habitats in Asia, Africa, &c. Except in its more elongated frustule, it scarcely differs from *C. striata*.

C. *transversalis* (Greg.).—Small, narrow-elliptic, with fine, parallel, dotted transverse striæ reaching the median line. Greg MJ. iii. pl. 4. f. 7. (VII. 37.) Scotland.

C. *atmospherica*, EM. pl. 39. 3. f. 9. Sciroceo dust. Ehrenberg's figure is large, elliptic, with median line and nodule and dotted parallel transverse striæ.

C. *hyperborea* (E.). — Large, elliptic, finely punctato-striate; striæ in the middle margin of the disc, 18 in 1-1200″, continued to the median furrow as puncta; the fine triple line of furrow with a single, distinct, transversely oblong median umbilicus. ERBA. xviii. p. 526; EM. pl. 35 A. 23. f. 4. Assistance Bay. Nearly resembles *C. Scutum* of New Holland. Breadth rather more than half the length.

C. *nigricans* (K.). — Narrow-elliptic, densely aggregated, girt by an entire, rather broad, brownish-black border; transverse striæ, 13 or 14 in 1-1200″. KB. p. 72, pl. 5. 8. f. 8. Trieste. β. *denudata*, border obsolete. KB. t. 5. 8, f. 10. 1-1320″ to 1-1200″.

C. *consociata* (K.). — Broadly elliptic, with a hyaline, longitudinal median line; disc with 13 punctated, almost radiant striæ on each side. KB. pl. 5. 8. f. 6. Marine. Baltic. 1-1320″.

C. *Pinnularia* (K.). — Roundish-elliptic, transversely striated, except a smooth, crenated, longitudinal median fascia. KSA. p. 52; KB. p. 73, pl. 5. f. 34. = *Cocconeis* ——?, BAJ. xlii. t. 2. f. 34. America. This very doubtful species was constituted by Kützing from Professor Bailey's figure.

C. *Persica* (Rab.). — Large, elliptic, with a longitudinal median line, dilated at centre and ends, and having 23 granulated transverse striæ on each side. Rab D. p. 27, pl. 3. f. 5. Persia.

C. *major* (Greg.). — Very large, thin, flat, broadly elliptic or suborbicular, with numerous delicate transverse striæ; median line with central and terminal nodules. GDC. p. 21, pl. 1. f. 28. Scotland. Hyaline, without distinct border; striæ about 54 in ·001″, somewhat concentric with extremities.

C. *Scutellum* (E.). — Elliptic, with finely punctated transverse striæ concentric with its extremities; striæ 18 in ·001″. EI. p. 194, pl. 14. f. 8; SBD. i. p. 22, pl. 3. f. 34. Marine. According to Ehrenberg, found in every quarter of the globe; yet he gives fewer habitats for this than for some other species. (IX. 162, 163.) β, nodule dilated into a stauros: S. *l. c.* pl. 30. f. 34. γ, disc with stauros, very fine striæ, and two lateral semioval markings: Ro MJ. vi. pl. 3. f. 9. Dorsum convex. 1-1150″. The species thus characterized is very variable in size and form and in the size of its puncta. Perhaps the varieties should be constituted distinct species.

C. *Arraniensis* (Grev.). — Valve ovate; striæ concentric with the extremities, faint, moniliform, contiguous, reaching the median line; striæ 30 in ·001″. Grev JMS. vii. p. 80, pl. 6. f. 2.

C. *speciosa* (Greg.).—Small, rhomboid-elliptic, with 12 distinctly granulated transverse striæ in ·001″, and somewhat concentric with extremities. Greg MJ. iii. pl. 4. f. 8. Scotland. So nearly allied to *C. Scutellum*, that, although its more distant striæ are formed of fewer and larger granules, we must doubt whether these species be really distinct.

C. *Mediterranea* (K.). — Elliptic or elliptic-oblong, with distinct puncta, regularly arranged so as to form both transverse and longitudinal series. KB. p. 73, pl. 5. 6. f. 8. Mediterranean Sea. Rather large; dorsum slightly convex. 1-840″ to 1-552″. In Kützing's figures the striæ appear somewhat concentric with extremities; and we doubt whether it be distinct from *C. Scutellum*.

C. *Peruviana* (K.).—Elliptic, regularly punctate, the larger puncta quadrate, more distant. KB. p. 73, pl. 5. 6. f. 7. Marine. Western shores of America. 1-840″. Kützing's figure seems very similar to *C. Mediterranea*.

C. *Adriatica* (K.). — Large, elliptic; striæ granulated, transverse on the disc, radiating on the margin. KB. p. 73, pl. 5. 6. f. 2 & 9. Adriatic and Mediterranean seas. 1-696″ to 1-480″. Dorsum convex. The striæ in Kützing's figures are concentric with the extremities; and this species seems to differ from *C. Scutellum* in its more distinct border.

C. *distans* (Greg.). — Elliptic, with somewhat attenuated ends, a delicate median line and transverse series of equal, rather distant granules. GDC. p. 18, pl. 1. f. 23. (VII. 38.) Scotland. This species agrees with *C. Scutellum* in its granulated striæ, somewhat concentric with extremities, but it appears to us distinct. The striæ are fewer, the granules far more conspicuous, and, according to Professor Gregory, equal, and situated on white, hyaline, faint bars,—characters absent in *C. Scutellum*.

C. *lamprosticta* (Greg.).—Large, rhomboid or broadly lanceolate with obtuse apices, a median line, and transverse series of rather distant conspicuous granules. Greg TMS. v. pl. 1. f. 28. Scotland. This species agrees with *C. distans* in having conspicuous transverse series of granules somewhat concentric with extremities, but differs in its elongated form.

C. *splendida* (Greg.).—Large, elliptic, with conspicuous, moniliform transverse striæ, a broad margin, and a median line dilated at centre and ends. GDC. p. 21, pl. 1. f. 29. Scotland. Striæ somewhat concentric with extremities, their granules near the margin being closer, and thus forming a continuous rim, with the median line terminating at its inner edge. Remarkable for its large size. Length about ·0044″; breadth ·0039″.

C. *Regina* (Johnston).—Valve ovate; striæ 20 in ·001″, concentric around the extremities, distinctly granular on either side the median line, in their course outwards faintly moniliform, more conspicuously so and forming a sort of border near the margin. Johnston, JMS. viii. p. 13, pl. 17. f. 1. Elide guano.

C. *punctatissima* (Grev.). — Elliptic, densely areolato-punctate; striæ moniliform, concentric with extremities; median line dilated at ends; rim simply striated. Grev MJ. v. p. 8, pl. 3. f. 1. Marine. Trinidad. Striæ 20 in ·001″. Dr. Greville says it differs from *C. Morrisii* in its finer, closer, and more minutely punctated striæ.

C. *crebrestriata* (Grev.). — Elliptic-oblong, delicately, closely, and uniformly punctato-striate; striæ concentric with extremities; median line straight, simple. Grev MJ. v. p. 9, pl. 3. f. 2. Trinidad. Length ·0022″ to ·0028″; breadth ·0012″ to ·0014″; striæ 30 in ·001″. The figure shows the ends of the valve more attenuated than usual in this genus.

C. *Grevillii* (S.).—Elliptic, with transverse costæ; striæ moniliform, 15 in ·001″. SBD. i. p. 22, pl. 3. f. 35. England, South Africa.

C. *regalis* (Grev.).—Valve orbicular; striæ moniliform, 5 in ·001″, occupying about a third of the diameter, externally continued by large distant granules, forming three or four concentric rows. Grev JMS. vii. p. 179, pl. 7. f. 1. Californian and Algoa Bay guanos. Striæ coarse, outer granules large and prominent, continued round the whole valve, but smaller near the extremities. Median line abbreviated.

C. *pinnata* (Greg.).—Valve oval; striæ concentric with the extremities, large, moniliform, not reaching the median line, but leaving a narrow elliptical blank space; median line distinct. Grev JMS. vii. p. 79, pl. 6. f. 1. Lamlash Bay.

C. *Parmula* (B.).—Broadly elliptic, with a median longitudinal line, having on each side 10 to 12 large, irregular transverse costæ (or sulci); surface with transverse granulated striæ. Bail. Proc. Phil. Acad. 1853. Tahiti.

C. *sulcata* (B.).—Broadly elliptic or suborbicular, with 30 to 40 transverse arcuate sulci. Bail. *l. c.* Puget's Sound.

C. *inconspicua* (Grev.).—Suborbicular, with a broad, rather strongly striated border; disc diaphanous, striæ faint, concentric with extremities, becoming obscure in the centre. Grev MJ. v. p. 9, pl. 3. f. 3. Trinidad. Diam. ·0011″; striæ 22 in ·001″. Dr. Greville's figure shows the striæ radiating rather than concentric with the extremities, and leaving a blank median space bisected by the median line and nodule.

C. *ornata* (Greg.).—Elliptic, with a strongly striated rim; disc with a lanceolate median blank space, bisected by a faint median line and large nodule; striæ somewhat radiant. GDC. p. 19, pl. 1. f. 24. Scotland.

C. *Finnica* (E.). — Ovate-oblong, slightly convex, smooth externally, but striated within. β larger, elliptic, three or four times longer than broad. EM. many figures. Ehrenberg gives about thirty habitats in Australia, Asia, America, and Europe. (XII. 41.) 1-570″ to 1-360″. Ehrenberg's figures do not agree with his description. They are elliptic with finely-dotted transverse striæ, and a blank, generally lanceolate longitudinal fascia, bisected by median line and nodule.

C. *Brundusiaca* (Rab.).—Very large, with very convex dorsum; disc elliptic-oblong, with from 22 to 24 somewhat diverging, transverse, granulated costæ, and an oblong central blank space bisected by a linear median line. Rab D. p. 28, t. 3. f. 16.

C. *margaritifera* (E.).—Broadly ovate, with subacute ends and transverse granulated striæ like rows of pearls. Marine. Bosphorus, South Africa. It is closely allied to *C. Americana*, but is rather larger and not curved.

C. *nitida* (Greg.).—Broadly oval, with suddenly contracted, subacute, short, point-like apices, transverse rows of very large pearl-like granules, and a narrow-lanceolate blank median space. GDC. p. 20, pl. 1. f. 26. Scotland. The granules are so arranged as to form both longitudinal and transverse series. Without the central nodule, which we have not detected, this species agrees with Rhaphoneis.

3* *Lateral view rhomboid.*

C. *rhombea* (E.).—Rhomboid, with about three longitudinal lines on each side the median suture. EM. pl. 35 A. 7. f. 2. Aquatic. Niagara. 1-1200″. Resembles *C. Americana*. With the exception of the median line and nodule, Ehrenberg's figure has no markings.

C. *Americana* (E.).—Small, rhomboid, with somewhat produced obtuse apices and faint (sometimes obsolete) dotted transverse striæ. KSA. p. 53. *C. Mexicana*, EA. t. 3. 5. f. 7. Mexico. (XII. 48.)

4* *Striæ decussating.*

C. *decussata* (E.). — Large, broadly elliptic, rough with decussating series of apiculi. KB. p. 73, pl. 28. f. 17. Cuba, India.

C. *rhombifera* (B.).—Broadly elliptic or suborbicular, with a sigmoid, obliquely longitudinal median line, running through a smooth space, attenuated at the ends and enlarged at the nodule into a rhomboid figure; surface decussately and transversely punctate. Bail. in Proc. Acad. Philad. 1853. Puget's Sound.

5* *Striæ transverse, separated into two series on each side the median line by a blank longitudinal fascia.*

C. *pseudo-marginata* (Greg.).—Large, broadly elliptical, with median line and nodules having on each side fine transverse striæ, interrupted and separated into two series by a longitudinal blank fascia. GDC. p. 20, pl. 1. f. 27. (VII. 39.) Scotland. Thin, transparent, the ends less rounded than in many species, median line not reaching the extremities, and enclosed in the lanceolate space formed by the convergence of the two lateral fasciæ.

C. *tæniata*, EM. pl. 6. 2. f. 12. Fossil. Morea. We have seen no description of this species. The figure represents it as elliptic, having its transverse striæ divided into two series on each side the median line and nodule by a longitudinal blank fascia, as in some species of Navicula.

6* *Disc with longitudinal concentric lines interrupted by radiating costæ.*

C. *radiata* (Greg.). — Elliptic, with rounded ends, about 8 concentric lines interrupted by numerous (18) strong rays proceeding from the umbilical nodule. Greg TMS. v. pl. 1. f. 26. Scotland.

C. *costata* (Greg.).—Valve oval, rather broad, median line conspicuous, nodule obsolete, marked with strong entire costæ reaching from the median line to the margin; spaces between the costæ striate; striæ at right angles to the costæ. Glenshira sand. Greg TMS. v. p. 68, pl. 1. f. 27.

7* *Median line and nodule excentric.*

C.? *excentrica* (Donkin).—Suborbicular, divided unequally by the median line, which does not reach the margin, and furnished with fine, dotted, transverse, converging striæ. Donkin, TMS. vi. pl. 3. f. 11. Marine. (VII. 40.) Northumberland. One of Dr. Donkin's interesting discoveries, remarkable for the excentric position of its median line and umbilical nodule, and probably the type of a new genus. The striæ converge towards the umbilicus, their puncta near the margin are closer and more distinct, forming a broad border.

8* *Transverse striæ and conspicuous margin.*

C. *coronata* (Bri.).—Valve oval; striæ transverse, reaching the conspicuous median line, surrounded by a costate band; spaces between the costæ punctate; costæ about 9 in ·001″; striæ 15 in ·001″. Bri JMS. vii. p. 179, pl. 9. f. 3. Shell cleanings. West Indies. The median line reaches only to the margin of the band; breadth of band ·0002″.

C. *fimbriata* (E.).—Valve oval, with a crenate intramarginal line; coarse transverse puncta reaching the median line. EB. 1858; Bri JMS. vii. p. 179, pl. 9. f. 43. Corsican Algæ. This species is readily distinguished by its peculiar looped margin.

Doubtful and undescribed Species.

C. *Navicula* (E).—Striated; the navicular side ovate; the front view narrow-linear, with an obscure median, longitudinal furrow. KSA. p. 53. Baltic, parasitic on *Bacillaria paradoxa*. 1-864″.

C. *paradoxa*, EM. pl. 9. 2. f. 5. Fossil. Puy de Dôme. Figures small, elliptic, smooth, with one or two median longitudinal lines and no nodule.

C. *Britannica* (Näg.).—Large, elliptic, smooth, with an accessory limb, marginal outwardly curved lines, and a distinct median nodule. KSA. p. 890. On British Algæ.

C. *tenuissima* (Näg.).—Elliptic, very thin, with concave venter and convex dorsum, sometimes with a narrow, opaque, crenulated limb. KSA. p. 890. On British marine Algæ. Varies in breadth and in presence or absence of striæ and accessory border.

C. disciformis (E.), *C. navicularis* (E), *C. Scutum* (E.), Swan River; *C. stellata* (E.), *C. undata* (E.), Western Asia; *C. tumida* (E.), River Jordan; *C. acuta* (E.), Ural Mountains; *C. turgida* (E.), Siberia; *C. Indica* (E.), *C. Bramaputra* (E.), *C. angusta* (E.), India; *C. Sol* (E.), Oasis of Jupiter Ammon, Africa; *C. Stella* (E), Teneriffe; *C. Glans* (E.), *C. Brasiliensis* (E.), *C. lirata* (E.), Brazil; *C. Morrisii* (S.), Black Sea.

FAMILY XV.—ACHNANTHEÆ.

Frustules genuflexed downwards, either free, adnate, or stipitate, each lateral surface having a median longitudinal line and the inferior one a central nodule or stauros also. The Achnantheæ, like the Cocconeideæ, have a nodule only on the inferior valve; but this is almost the only point of resemblance. The bent frustule and dissimilar lateral surfaces distinguish this family from every other. In their mode of growth the Achnantheæ resemble the Biddulphieæ.

Genus ACHNANTHIDIUM (Kütz.).—Frustules unattached, solitary or few together, rarely numerous, in front view linear, bent; ventral valve with median line and central and terminal nodules; dorsal valve without a central nodule. The Achnanthidia resemble unattached frustules of Achnanthes, but are generally very minute, and their proper position is still somewhat doubtful. "Admitting it to be proved that in the species of this genus there positively exists a median nodule in one of the lateral surfaces and not in the other, and that two puncta exist in the extremities of the primary surfaces, as stated in the definition of the order and in that of the family,—admitting this, we should still have to decide whether the uncertain relations of these characters to other families, and their inconstancy, will give us any right to erect a distinct genus on principles so slight and precarious" (Meneghini).

* *Frustules minute, smooth or obscurely striated.*

ACHNANTHIDIUM *microcephalum* (K.).—Frustules extremely minute; valves lanceolate, with capitate apices; striæ obsolete. KB. p. 75, pl. 3. f. 13 & 19; SBD. ii. p. 31, pl. 61. f. 380. Fresh water. Europe. (XIV. 15.) Front view narrow-linear. 1-1680″.

A. *trinode* (Ar.).—Frustules geniculate; valves with one central and two terminal inflations; median line and central nodule distinct; extremities rounded; striæ obscure. = *Navicula trinodis*, SBD. ii. p. 94. Fresh water. Britain. (VIII. 9.)

A. *lanceolatum* (Bréb.).—Frustules minute; valves oblong-lanceolate, with obtuse ends and turgid centre; striæ obscure. Bréb. in KSA. p. 54; SBD. ii. p. 30, pl. 37. f. 304. Fresh water. Europe. Frustules 2 to 100; striæ 40 in ·001″, S. The transverse band of the lower valve sometimes extends to both margins, sometimes is bifid, and on one half only.

A. *delicatulum* (K.).—Frustules minute; valves ventricose, with rostrate ends. KB. p. 75, pl. 3. f. 21. *Falcatella delicatula*, Rab D. p. 46, t. 5. f. 4. Submarine. Germany. (XIV. 16.) 1-1680″.

A. *cryptocephalum* (Näg.). — Valves lanceolate-linear, with the subacute apices attenuated or obsoletely capitate. Näg. in KSA. p. 890. Switzerland.

A. *lineare* (S.). — Frustules minute; valves linear, obtuse, upper with median line only, lower with median line and nodules; striæ obscure. SBD. ii. p. 31, pl. 61. f. 381. Fresh water. Scotland.

A. *flexellum* (K., Bréb.).—Valves oblong, with gibbous middle and very obtuse ends; median line sigmoid. Bréb. KSA. p. 54. = *Cymbella* (?) *flexella*, KB. p. 80, pl. 4. f. 14; Rab D. p. 23, pl. 7. f. 15; *Achnanthes Bavarica*, ERBA. 1853, p. 526; *Cocconeis Thwaitesii*, SBD. i. p. 21, pl. 3. f. 33. Fresh water. Europe. 1-650″; striæ indistinct; front view with genuflexed venter, convex dorsum, obtuse ends, and a notch-like punctum at the middle of the lower margin.

2 * *Frustules large, distinctly striated.*

A. *coarctatum* (Bréb.).—Valves elongated, linear-oblong, constricted at the middle, with slightly attenuated, obtuse ends, striæ distinct. Bréb. in SBD. ii. p. 31, pl. 61. f. 379. = *Achnanthidium Otrantinum*, Rab D. p. 25, pl. 8. f. 3; *Achnanthes binodis*, EM. pl. 34. 5 B. f. 1?. Fresh water. Europe, Africa, America. (VII. 41.)

Genus ACHNANTHES (Bory St.-Vinc., Ag.). — Frustules bent, solitary or aggregate, attached to a stipes, a central nodule in the lower or ventral valve only. The frustules are bent downwards; so that the upper margin is convex, the lower one concave. In some species the lateral portions are turgid, the central one looking like a band between them; in others they do not enter into the front view. The superior lateral surface differs from the lower in the absence of the central transverse pellucid line and central nodule, the latter appearing like a punctum in the front view. A median longitudinal line is present in both valves. In their obscure striæ "three species (*minutissima, exilis, parvula*) present great analogy of form with the preceding genus. In one of these (*parvula*) there is wanting the characteristic angular bending, for which reason it becomes very similar to Odontidium and Diadesmis. The other species (*striatæ*) differ only by very slight characters from each other" (Meneg.).

* *Valves divided by two constrictions into three lobes.*

ACHNANTHES *ventricosa* (E.).—Valves divided by two constrictions into three oblong inflations; apices rounded; striæ distinct. EM. t. 1. 2. f. 9; t. 1. 3. f. 18, 19. = *Monogramma ventricosa*, E. Asia, Africa, America.

2 * *Valves distinctly striated, not three-lobed. Marine.*

† Valves costate.

A. *longipes* (Ag.).—Gregarious; valves elliptic-oblong, costate, with moniliform striæ between the costæ. ASA. p. 1; KB. p. 77, pl. 20. f. 1; SBD. ii. p. 26, f. 300. = *Conferva stipitata*, Eng. Bot. t. 2488; *A. Carmichaëlii*, Grev. in Br. Fl. ii. p. 404. (VII. 42.) On Marine Algæ. Europe, America. Few-pointed; frustules large, with stout elongated stipes; front view turgid, with convex dorsum. 1-570″ to 1-120″.

2 † Valves striated, but not costate.

A. *brevipes* (Ag.).—Gregarious; valves oblong, with attenuated acute ends; striæ distinct, moniliform, 20 in ·001″; stipes stout, short. Ag CD. p. 59; SBD. ii. p. 27, pl. 37. f. 301. Marine. Europe, America. (X. 199–202.) Frustules large, very turgid in front view, with convex dorsum. 1-860″ to 1-180″.

A. *salina* (K.). — Frustules striated, very turgid, obtuse-angled, genuflexed, with slightly notched venter; valves broadly linear, with cuneate ends; striæ punctated; stipes very short, thick. KB. p. 77, pl. 20. f. 5. Salt marshes. Europe. Differs from *A. brevipes* only in its more linear valves and cuneate ends. Professor Smith was probably right in uniting them.

A. *intermedia* (K.). — Few-jointed; frustules striated, obtuse-angled, turgid; valves sublinear, with acutely cuneate ends; stipes short, distinct, fine. KB. p. 76, pl. 20. f. 6. On *Enteromorpha intestinalis*. Germany, France. Smaller than *A. brevipes*, with less turgid dorsum and finer striæ; but we doubt whether they are truly distinct.

A. *rhomboides* (E.).—Frustules large, striated, very turgid, nearly straight; valves broadly lanceolate, almost rhomboid, with acute apices; stipes short, thick. EA. p. 121. = *A. ventricosa*, KB. p. 76, pl. 20. f. 7. Marine. America, Europe.

A. *multiarticulata* (Ag.). — Frustules striated, turgid, with rather obtuse angles; valves elliptic-lanceolate; stipes stout, short. Ag CD. p. 59; KB. p. 76, pl. 20. f. 8. Marine. Europe. 1-312″.

A. *Capensis* (K.).—Frustules striated, turgid, obtuse-angled; valves lanceolate-elliptic or oblong; stipes elongated, stout. KB. p. 76, t. 21. f. 1. Marine. Cape of Good Hope. 1-600″. It varies with few or many frustules.

A. *bacillaris* (E.).—Frustules narrow, striated, each slightly inflexed at the middle, both dorsally and ventrally equally bacillar, with rounded ends; stipes short. ERBA. 1843, p. 256. Marine. Venice. Often in long series. It is smaller than *A. longipes*, and more slender than *A. brevipes*, E.

A. *subsessilis* (K.).—Scattered, of few frustules; valves linear-oblong, with rounded ends; striæ moniliform, 24 in ·001″; stipes nearly obsolete. KB. p. 76, t. 20. f. 4; SBD. ii. p. 28, pl. 37. f. 302. = *Achnanthes turgens*, EA. p. 121. Common on filiform species of Enteromorpha in salt marshes. Europe, America. 1-1150″ to 1-430″. (VII. 43.) Easily recognized by its all but sessile frustules.

A. *angustata* (Grev.). — Front view narrow; length ·0060″; breadth ·0004″; striæ 24 in ·001″. Grev MJ. vii. p. 163, pl. 8. f. 9. In Californian guano. "The striæ agree in number with those of *A. subsessilis*; the relative length and breadth, however, of the valve, as seen in the front view, is so widely different from the proportions of the species above mentioned, that the possibility of its being a variety cannot be entertained" (Greville).

A. *cristata* (Rab.). — Valves oblong-elliptic; striæ gently curved, coarsely moniliform, distant, 9 to 10 in ·001″. Rab D. p. 26, pl. 8. f. 7. Italy.

A. *genuflexa* (K.). — Frustules small, striated, turgid, obtuse-angled, strongly bent; stipes short, rather stout. KB. p. 76, pl. 21. f. 3. Marine. Genoa.

A. *Gregoriana* (Grev.). — Front view of frustule broadly linear; striæ very fine; length ·0060″ to ·0080″; breadth ·0010″ to ·0015″. Grev MJ. vii. p. 84, pl. 6. f. 13, 14. Marine. Scotland. In point of size it rivals *A. longipes*, but is widely separated from it in the character of the striation alone, to perceive which requires not only a good object-glass but delicate manipulation. As in many of its congeners, the frustules vary greatly in both length and breadth (Grev.).

A. *pachypus* (Montagne). — Frustules small, finely striated, obtuse-angled, rather turgid; valves elliptic-oblong; stipes stout, very short. Mont. Flor. Boliv. pl. 1; KB. p. 76, pl. 29. f. 83. Marine. Europe, Asia, America. 1-1730″ to 1-1320″.

A. *parvula* (K.). — Frustules minute, nearly straight, obtuse-angled; valves elliptic-oblong, obtuse, finely striated; stipes rather stout. KB. p. 76, t. 21. f. 5. On Enteromorpha in brackish water. Europe. Frustules stouter than in *A. exilis*.

3 Very minute; striæ wanting or indistinct. Fresh water.*

A. *exilis* (K.). — Frustules slender, linear; valves lanceolate, tapering to the subacute apices; striæ indistinct; stipes slender, elongated. KB. p. 76, t. 21. f. 4; Ralfs, ANH. xiii. p. 14. f. 12; SBD. ii. p. 29. Fresh water. Europe, Asia, America. (VII. 44.) *A. exilis* is easily known by its minute, slender, hyaline frustules from every other species except *A. minutissima*. From that species it differs by its tapering, more lanceolate and acute valves; and by its elongated stipes.

A. *minutissima* (K.).—Frustules slender, linear; valves linear-oblong, with rounded ends; striæ obsolete; stipes fine, shorter than the frustule. KB. p. 75, pl. 13. f. 2 *c*; Ralfs, ANH. xiii. pl. 14. f. 11. Fresh water. Europe. We formerly considered this a variety of *A. exilis*, and, still doubting whether the differences are constant, think that Professor Smith may rightly have united them.

Doubtful Species.

A.? *arenicola* (Bail.).—Frustules minute, rectangular or slightly curved; valves lanceolate, striate; stipes short. Bail. Sm. Cont. ii. p. 38, pl. 2. f. 19. Marine. America. It is possibly a species of Hyalosira, but requires further study (Bail.).

A. *australis*, EM. pl. 35 A. 2. f. 1. South Africa. Frustules linear, uniformly curved, with truncate ends and striated margin.

A.? *inæqualis* (E.). — Unequally bent and smooth. EM. pl. 16. 1. f. 45, & pl. 17. 2. f. 25. Fossil. Sweden, Finland.

A.? *paradoxa* (E.).—Frustules ovate, obtuse, twice as long as broad, with 16 transverse, scabrous, punctated lines in 1-1152″. ERBA. 1845, p. 73. Fossil. United States. 1-900″. No nodule observed, E.

Species known to us only by name.

A. turgida (E.), Australia, America; *A. Indica* (E.), India; *A. Javanica* (E.), Java; *A. obtusa* (E.), Africa; *A. Semen* (E.), America; *A. Brasiliensis* (E.), Brazil; *A. incrassata* (E.), America.

Genus CYMBOSIRA (Kütz.).—Frustules as in Achnanthes, stipitate, connected into series by a gelatinous process or hinge (isthmus). Cymbosira differs from Achnanthes by the same character as Diatoma from Fragilaria.

CYMBOSIRA *Agardhii* (K.). — Frustules linear, slightly curved, with rounded apices; valves linear, oblong, scarcely dilated at the middle, with rounded obtuse apices. KB. p. 77, pl. 20. f. 3. =*Achnanthes seriata*, Ag CD. Marine. Venice, Cayenne. (XIV. 14.). 1-960″ to 1-288″. Stipes very short.

Genus MONOGRAMMA (Ehr.).—Frustules furnished with transverse pinnules, a median, transverse, linear band on one valve only, three ventral nodules and two dorsal. (=Stauroptera with a stauros on one valve only, or to a solitary Achnanthes with terminal puncta.—ERBA. 1843, p. 136.) Notwithstanding Ehrenberg's remarks, we cannot distinguish this genus from Achnanthidium. The species are known to us only by name.

MONOGRAMMA *Achnanthes* (E), India. *M. trinodis* (E.), Sandwich Islands. M. *ventricosa* (E.) = *Achnanthes ventricosa.*

FAMILY XVI.—CYMBELLEÆ.

Frustules cymbiform; valves lunate, with a longitudinal line, and marginal or subcentral nodule. In shape the Cymbelleæ are very similar to the Eunoticeæ, but they differ essentially both from them and the Naviculeæ by the median nodules of the lateral surfaces being marginal or submarginal.

Genus CYMBELLA (Ag., Kütz.).—Frustules free, cymbiform; transverse striæ interrupted by a longitudinal line having central and terminal nodules, and dividing the valve into unequal portions. The frustules, in the lateral view, have one margin (dorsum) convex, and the other (venter) straight, or at least less developed. In consequence of this form, the longitudinal line divides the surface unequally, being much nearer the lower margin. Cymbella includes species distributed in the genera Cocconema, Navicula, and Pinnularia of Ehrenberg's system.

* *Valves with one margin triundulate.*

CYMBELLA *Arcus* (Greg.). — Valves slender, semilanceolate, with straight venter, convex, triundulate dorsum, and produced, minute, capitate apices. Greg. in MJ. iv. p. 6, pl. 1. f. 21; SBD. ii. p. 85. Scotland. Minute; longitudinal line and nodules submarginal; transverse striæ very fine, 40 in ·001″.

C. *sinuata* (Greg.).—Valves lanceolate, with subcapitate apices, gently convex dorsum, and triundulate venter. Greg. MJ. iv. p. 4, pl. 1. f. 17. Scotland. Minute; transverse striæ conspicuous, about 20 in ·001″, scarcely reaching the median line.

2* *Valves without triundulate margins.*

† Valves with produced or capitate apices.

C. *Ehrenbergii* (K.).—Valves broadly lanceolate, with unequal sides, suddenly contracted into rather obtuse, slightly produced apices; transverse striæ distinct, punctate, 12 in 1-1200″. KB. p. 79, t. 6. f. 11; SBD. i. p. 17, pl. 2. f. 21. =*Navicula inæqualis*, E Inf. t. 13; *Pinnularia inæqualis*, EM. many figures. Common, both recent and fossil. Europe, Asia, Africa, America. (VII. 46; IX. 154.) Large; length 1-216″. Differs from a Navicula only in having one margin of the valves less convex than the other.

C. *heteropleura* (E., K.). — Valves broadly lanceolate, with unequally convex sides, suddenly contracted into short, broad, very obtuse, beak-like apices; striæ distinct. KB. p. 79. = *Pinnularia heteropleura*, EM. pl. 5. 2. f. 11. North America. Large; allied to *C. Ehrenbergii*, but with more obtuse apices.

C. *cuspidata* (K.). — Valves broadly lanceolate, with unequally convex sides, suddenly contracted into subacute, short, rostrate apices; striæ delicate, 18 to 20 in 1-1200″. KB. p. 79, t. 3. f. 40; SBD. i. p. 18, pl. 2. f. 22. Europe. 1-576″. (VII. 45.) Differs from the preceding species in its smaller size, more graceful form, and narrow beaks.

C. *rostrata* (Rab.). — Valves semilunate, with dorsum strongly and venter slightly convex; ends produced into short, subacute beaks; striæ dotted, converging, 12 or 13 in 1-1200″. Rab D. p. 22, pl. 7. f. 5. Italy. Small. Very nearly allied to *C. cuspidata*.

C. *porrecta* (Rab.). — Valves turgid-lanceolate, with unequal margins; ends produced into rather long, stout, obtuse beaks; striæ stout, somewhat converging, 6 in 1-1200″. Rab D. p. 22, pl. 10. f. 10. Italy. Venter less turgid than the dorsum.

C. *fornicata* (Rab.).—Valves lunate, with very fine convex dorsum, gibbous venter, and produced, obtuse, rostrate ends; striæ fine, smooth, 7 or 8 in 1-1200″. Rab D. p. 22, pl. 10. f. 9. Persia.

C. *amphicephala* (Näg.). — Smooth; valves elliptic, with unequal sides and produced capitate apices; front view oblong with truncate ends. KSA. p. 890. Switzerland.

C. *æqualis* (S.). —Valves lanceolate, nearly symmetrical, with shortly produced, slightly curved, obtuse extremities; striæ fine, 30 in ·001″. SBD. ii. p. 84; Grev. in ANH. 2 ser. xv. pl. 9. f. 4. Britain. A very distinct species, which differs from Navicula only by the slightly curved ends, Grev.

C. *pachycephala* (Rab.).—Valves semilunate, curved, with very convex dorsum and gibbous venter, strongly constricted beneath the produced capitate apices; striæ granulate, somewhat converging, 7 or 8 in 1-1200″. Rab D. p. 22. = *C. eurycephala*, Rab. t. 7. f. 10. Servia.

C. *epithemioides* (Rab.).—Valves arcuate, with convex dorsum, concave venter, and produced, obtuse, slightly recurved ends; striæ stout, somewhat converging, 6 in 1-1200″. Rab D. p. 22. = *C. costata*, Rab. t. 7. f. 16. Salzburg. Like an Epithemia, but having a central nodule.

C. *Gregorii* (Ralfs). —Valves arcuate, with convex dorsum, straight venter, and slightly produced truncate apices; striæ distinct. = *C. truncata*, Greg. in MJ. iii. p. 38, pl. 4. f. 3. Scotland. Small.

C. *turgida* (Greg.). — Valves lunate, with turgid, convex dorsum, nearly straight venter, and produced, minute, acute apices; striæ very conspicuous, about 24 in ·001″. Greg MJ. iv. p. 5, pl. 1. f. 18. Scotland, America.

C. *Pisciculus* (Greg.).—Valves lanceolate, with convex dorsum, nearly straight venter, and obtuse, subcapitate apices; striæ about 30 in ·001″. Greg. in MJ. iv. p. 6, pl. 1. f. 20. Britain.

C. *excisa* (K.). — Valves semilunate, with slightly recurved, produced apices, very convex dorsum, and a straight venter, notched at its middle; striæ 16 in 1-1200″. KB. p. 80, pl. 6. f. 17. Europe. Minute.

2 † Apices neither rostrate nor capitate.

C. *affinis* (K.). — Valves lanceolate, with subacute, scarcely produced apices, and the dorsal margin more convex than the ventral; striæ faint, 19 in 1-1200″. KB. p. 80, pl. 6. f. 15; SBD. i. p. 18, pl. 30, f. 250. = *Cocconema Fusidium*, EM. many figures. Europe, Asia, Australia, Africa, America. Minute; terminal nodules large. 1-1150″ to 1-620″.

C. *delicatula* (K.).—Valves unequally and narrowly lanceolate, smooth. KSA. p. 59. France. Minute. 1-1200″.

C. *obtusiuscula* (K.).—Valves lanceolate, with one margin rather less convex than the other; apices somewhat obtuse, not produced; striæ fine, 18 to 20 in 1-1200″. KB. p. 79, pl. 3. f. 68. Europe. 1-600″. Differs from a Navicula only by its slightly unequal margins.

C. *Helvetica* (K.).—Valves elongated, somewhat arched, slender-lanceolate, with slightly gibbous venter, and rather obtuse apices; striæ fine, granulated, 13 or 14 in 1-1200″. SD. i. p. 18, pl. 2. f. 24. Europe. (XIV. 24–28.) Large. 1-264″ to 1-240″. Front view oblong, truncate. Akin to *C. gastroides*, but more slender, K.

C. *maxima* (Näg.). — Valves slender, with attenuated, rather obtuse ends, and inflated venter; striæ 16 in 1-1200." KSA. p. 890. Switzerland. 1-180" to 1-120".

C. *gastroides* (K.). — Valves lunate, with obtuse apices; venter slightly concave, with gibbous centre; striæ granulated, 11 or 12 in 1-1200". KB. p. 79, pl. 6. f. 4 *b*. Europe. (XIV. 18-20.) Large.

C. *truncata* (Rab.).—Valves as in *C. gastroides*, but with broadly truncate apices. Rab D. p. 21; *C. fulva*, t. 7. f. 3. = *C. gastroides*, KB. p. 79, pl. 6. f. 4 *a*. Europe.

C. *leptoceras* (E., K.).—Valves slender, arcuate, with gibbous venter and attenuate apices; striæ very fine, 17 in 1-1200". KB. p. 79, pl. 6. f. 14. = *Cocconema leptoceras*, EA and M. many figures. Europe, Asia, Australia, Africa, and America. Minute; front view elliptic-oblong, with rounded ends.

C. *maculata* (K.).—Valves semiorbicular, with very convex dorsum and straight or gibbous venter; striæ very fine, 12 to 13 in 1-1200". KB. p. 79, pl. 6. f. 2. = *C. Lunula*, Rab D. p. 23. = *Cocconema Lunula*, EA and M. many figures. Common. Europe, Asia, Africa, America. Minute; front view elliptic, with truncate ends.

C. *obtusa* (Greg.).—Valves semi-oval, with very obtuse apices, convex dorsum, and nearly straight venter; striæ very fine, inconspicuous, about 36 in ·001". Greg MJ. iv. p. 5, pl. 1. f. 19. Scotland. Minute.

C. *ventricosa* (Ag.).—Valves semilunate, with very convex dorsum, straight venter, and large, distinct terminal nodules; striæ inconspicuous, 30 in ·001". Ag CD. p. 9; KB. p. 80, pl. 6. f. 16; SBD. ii. p. 84. Europe. Minute. 1-1000". Front view oblong, with truncate ends.

C. *microstoma* (Rab.).—Valves lunately curved, with broadly obtuse ends; dorsum convex, depressed at the centre; venter concave; nodules very minute; striæ smooth, 7 or 8 in 1-1200". Rab D. p. 22, t. 10. f. 3. Persia.

C. *Scotica* (S.).—Valves slender, semilanceolate, with straight ventral margin and acute apices; striæ 42 in ·001". SD. i. p. 18, pl. 2. f. 25. Britain.

C. *gracilis* (E., K.). — Valves slender, semilanceolate, with straight or slightly concave ventral margin and subacute apices; striæ very fine or obsolete, 17 in 1-1200". KB. p. 79, pl. 6. f. 9. = *Cocconema gracile*, EM. several figures. Europe, Asia, Africa, America. Lough Mourne deposit. Small. 1-840" to 1-600".

C. *lunata* (S.).—Valves narrow, lunate, with slightly concave venter, and rather obtuse apices; striæ distinct, 24 in ·001". SBD. ii. p. 84. Grev. in ANH. 2nd ser. xv. pl. 9. f. 5. Scotland. Distinguished from *C. Helvetica* by its smaller size and concave venter, and from *C. Scotica* by its coarser striæ and obtuse ends, Grev.

C. *curvata* (Rab.).—Valves smooth, lunate, with convex dorsum, slightly concave venter, and obtuse ends. Rab D. p. 23, t. 7. f. 14. 6. Italy.

C.? *Dianæ*, E. = *Cocconema Dianæ*, EM. pl. 15 A. f. 100 *a*. Lough Mourne deposit. Small. Valves lunate, with convex dorsum, concave venter, and obtuse apices.

C.? *Navicula* = *Cocconema Navicula*, EM. pl. 17. 2. f. 35. Finland. —Valve lanceolate, with the dorsum rather more convex than the venter.

Genus COCCONEMA (Ehr.). — Frustules cymbiform, stipitate; lateral surfaces lunate, striated, and divided unequally by a longitudinal line with median and terminal nodules. The frustules are similar in form to those of Cymbella, and when detached, their proper genus is often doubtful; the lower margin, however, is less frequently convex than it is in Cymbella.

COCCONEMA *lanceolatum* (E.).—Front view lanceolate, truncate; valves elongated, arcuate, or semilanceolate, centre of venter gibbous; striæ moniliform, 21 in ·001". EI. t. 19. f. 6; SBD. i. p. 75, pl. 23. f. 219. Europe, Asia, Australia, Africa, America. (x. 194, 195.) Length 1-210" to 1-120". Ventral margin of frustule nearly straight, with slightly gibbous centre; stipes dichotomous, articulated.

C. *asperum* (E.).—Habit and size of *C. lanceolatum*, but with striæ denticulate or interrupted by puncta. EM. many figures. Australia, Asia, America; fossil, France. 1-288". We fear this form is scarcely distinct from *C. lanceolatum*.

C. *fossile*, EM. t. 19. f. 57. Greece. Ehrenberg's figure represents a smaller species than *C. asperum*, with straight ventral margin, nearly marginal longitudinal line and nodules, and denticulate striæ.

C. *Bremii* (Näg.).—Pulvinate; valves slender, sublunate, with attenuated ends and obtuse apices; striæ very fine. KSA. p. 890. Rocks in streams. Switzerland. Large; stipes long, articulated; frustules in front view lanceolate.

C. *cornutum* (E.).—Valves slender; lunate, gradually tapering into long ends, with obtuse apices; venter concave, gradually tumid at its middle. EM. pl. 15 A. f. 94. America, Berlin. Lough Mourne deposit. Large; differs from *C. lanceolatum* in its more slender and tapering form.

C. *Mexicanum* (E.).—Stout; valves lunate, with obtuse, slightly produced ends; ventral margin slightly tumid; dorsum very convex; striæ 18 in 1-1152″, distinctly and elegantly granulose. EM. pl. 33. 7. f. 6, 7. Mexico. Large. 1-206″.

C. *Cistula* (E.).—Valves lunate, with very convex dorsum, and the concave venter tumid at its centre; stipes elongated, filiform, subsimple. EI. t. 19. f. 7; SBD. i. p. 76, pl. 23. f. 221. = *Gomphonema semi-ellipticum*, Ag CD. p. 33; *G. simplex*, KSA. p. 37. Europe, Asia, America. (x. 196–198.) 1-1150″ to 1-430″. Front view elliptic-oblong, with obtuse ends.

C. *Græcum* (E.).—Habit of *C. Cistula*, but with stronger and fewer striæ, 12 to 13 in 1-576″. ERBA. 1840, p. 12. Greece. 1-575″.

C.? *biceps* (E.).—Valves turgid, semi-oval, each ends in a flat and tumid margin, suddenly rostrate, obtuse; sides longitudinally sulcate and transversely striate. ERBA. 1845, p. 362. Marine. India. 1-576″. Habit of *C. Cistula*.

C. *cymbiforme* (Ag., E.).—Slender; valves lunate, with somewhat obtuse apices; venter straight or slightly concave, with rather tumid centre; stipes intricate, forming a compact gelatinous mass. EI. pl. 19. f. 8; SBD. i. p. 76, pl. 33. f. 220. = *Cymbella cymbiformis*, Ag CD. p. 10; *Frustulia cymbiformis*, KSA. Europe, Asia, America. (XII. 46.) 1-500″ to 1-150″. Transverse striæ 16 in 1-1200″. Front view linear-lanceolate, with truncate ends. It forms a brownish compact covering on rocks, which is frequently of considerable thickness and extent.

C.? *acutum* (E.).—Slender, slightly curved, smooth (?), with acute ends; ventral margin slightly tumid in the middle. EA. p. 123. Labrador, Falaise?. Small; habit of a curved *Navicula amphioxys*.

C. *tumidum* (Bréb.).—Valves semilunate, with obtuse, scarcely produced ends; ventral margin nearly straight; front view lanceolate, with truncate apices. KSA. p. 60. France. Small. 1-576″. Striæ 16 in 1-1200″. Stipes elongated, filiform, simple.

C. *affine* (K.).—Valves lunate, with very convex dorsum; stipes intricate. KSA. p. 59. France. Minute. Resembles *Cymbella affinis*, but is stipitate.

C. *gibbum* (E.).—Valves semielliptic, with truncate, slightly produced apices; transverse striæ very delicate. KB. t. 6. f. 6. Europe, Asia. (XIII. 10.) 1-480″. β sessile. Stipes obsolete. = *Cymbella Orsiniana*, Rab D. p. 23.

C. *Arcus* (E.).—Semilunate, with obtuse apices; dorsum very convex, venter not gibbous. EM. several figures. Asia, America, Lough Mourne deposit.

C. *parvum* (S.).—Valves lunate, with subacute ends; ventral margin scarcely gibbous; front view nearly linear. SBD. i. p. 76, pl. 23. f. 222. (VII. 47.) Cliff, Beachy Head. Minute. ·0009″ to ·0016″. Striæ 21 in ·001″.

C. *Saxonicum* (Rab.).—Valves semilunate, with acute ends; ventral margin straight or slightly concave; dorsum very convex; striæ faint. Rab D. p. 24, t. 10. f. 11. Saxony. Minute. The front view is figured as oblong, with truncate ends, and the stipes dilated beneath the frustule.

C. **Boeckii** (E.).—Valves elongated, lanceolate, with subacute apices; front view linear-lanceolate, obtuse; striæ 26 in 1-1200″. E Inf. t. 19. f. 5. = *Gomphonema lanceolatum*, Ag CD. p. 34; *Doryphora Boeckii*, SBD. i. p. 77, pl. 24. f. 223. Marine. Europe. Large. 1-210″ to 1-120. Stipes dichotomously divided. (VII. 48.) This species is no doubt wrongly referred to Cocconema, since both margins of the lateral valves are symmetrical. We regard it as a stalked Navicula, and find a central, though inconspicuous, nodule—a fact which, we think, forbids it being placed in Dorypora as Professor Smith proposed.

Species known to us only by name.

C. *subtile* (E.), Asia, America; *C. cingulatum* (E.), Georgia; *C. Javanicum* (E.), Java; *C. Araucaniæ* (E.), America.

Genus SYNCYCLIA (Ehr.)—Frustules cymbiform, connected in a circular manner within an amorphous gelatinous substance. "Whenever the lateral surfaces are inclined to each other by the different extension of the two primary surfaces, the associated series must be formed circularly" (Meneg.).

SYNCYCLIA *Salpa* (E.). — Frustules semi-oval, smooth, mostly connected, in sixes, into short tubes or rings; colouring matter pale green. E Inf. p. 233, t. 20. f. 11; KSA. p. 61. Marine, near Wismar. (VII. 53; X. 206.) Length 1-2300″ to 1-570″. When dry, longitudinally plicate.

S. *quaternaria* (E.).—Frustules binate or quaternate, smooth; colouring matter golden- or reddish-brown. ERBA. 1840, p. 22; KSA. p. 61. Marine. Europe. 1-864″.

Species known to us only by name.

S. *granulata* (E.), Georgia; S. *Amphora* (E.), Palestine.

Genus ENCYONEMA (Kütz.).—Frustules cymbiform, arranged in longitudinal series within submembranous tubular filaments. Valves divided unequally by median line and nodules. "Encyonema differs from Schizonema and other frondose genera of Diatomaceæ in the form of its frustules, a single frustule resembling one of Cymbella or Cocconema. It is more probable that some bodies, which are really congeries of the ova of certain insects, will be at first sight classed with Encyonema; but these ova, although cymbiform and arranged in longitudinal series, are neither siliceous nor striated..... The lateral surfaces of the frustule, being convex, are observed in the front view, in which also the frustules are quadrilateral, with two puncta at each end. These puncta are less easily discerned in the dorsal view, and the dorsum is longitudinally convex. The lateral view is semielliptic, with numerous transverse striæ, which are interrupted, as in Cocconema, by a longitudinal pellucid line" (Ralfs). Professor Smith says that the frustules of Encyonema, even when removed from the frond, may be distinguished from those of Cymbella, "as the terminal nodules of the median line in Cymbella are placed at the extremities of the valves, while in Encyonema they are removed to some distance above, and occupy a place nearer the central nodule."

ENCYONEMA *prostratum* (Berk., Ralfs). — Filaments subsimple; valves with rounded, mostly incurved ends; striæ 18 in ·001″. Length ·0016″ to ·0024″. Ralfs, ANH. 1st ser. xvi. pl. 3. f. 3; KSA. p. 61; SD. ii. p. 68, pl. 54. f. 345. = *Monema prostratum*, Berk BA. pl. 4. f. 3; *Schizonema prostratum*, Grev BFl. p. 414; *Encyonema paradoxum*, E Inf. p. 237; *Glœonema Leibleini*, Ag CD. p. 31? Europe, Asia, America. The valves have a depression beneath each apex; sometimes the depression is very slight, at others so deep and notch-like that the ends become rostrate. The former condition is the *E. paradoxum* of Kützing. (VII. 49; XIV. 22.)

E. *Auerswaldii* (Rab.).—Valves with very convex dorsum, slightly gibbous venter, and contracted, produced, obtuse ends; striæ 11 or 12 in ·001″. Rab D. p. 24, pl. 7. f. 2. Leipzig.

E. *cæspitosum* (K.).—Filaments erect, tufted, much interwoven; valves with convex dorsum, slightly tumid venter, and straight, slightly produced, obtuse ends; striæ 24 in ·001″. KSA. p. 61; SBD. i. p. 68, pl. 55. f. 346. = *E. prostratum*, KB. p. 82. Europe. The frustules are smaller than those of *E. prostratum*.

E. *triangulum* (E., K.).—Valves with very convex, gibbous dorsum, slightly convex venter, and produced, acute apices. KSA. p. 62. = *Glœonema triangulum*, ERBA. 1845, p. 77; EM. t. 35 A. 7. f. 10. River Niagara. Dorsum so turgid as to give the valve a triangular outline. "It is a very remarkable circumstance, that I often found two different sorts of frustules in the same tube —one very delicate and straight like a Naunema, the other the large curved kind. Even to the present moment I cannot explain this phenomenon; for both sorts were in considerable quantities and quite free, and therefore it is difficult to suppose one a parasite" (E.).

E. *Sinensis* (E.). — Valves oblong,

striated, with the habit of Cocconema, but suddenly reflexed under the very obtuse apices in the manner of Eunotia. = *Glœonema Sinense*, ERBA. 1847, p. 484; EM. China, Java. Ehrenberg's figure represents the valve distinctly striated, with straight venter, very obtuse, rounded ends, and the dorsal margin very convex, and curved upwards at each end.

E. *gracile* (Rab.).—Valves slender, with truncate apices, slightly gibbous middle and indistinct striæ. Rab D. p. 26, pl. 10. f. 1. Salzburg. Frustules minute.

Doubtful Species.

E. *globiferum* (Ag.).—Filaments abbreviated, frustules simple or binately conjoined, hyaline, with a globule in the middle. = *Glœonema globiferum*, Ag CD. p. 31. Italy.

E. *Arcus* = *Glœonema Arcus*, ERBA. 1856, p. 333, f. 26. Africa.

Genus AMPHORA (Ehr.).—Frustules free, cymbiform; lateral view lunate or arcuate, with a nodule at the middle of the ventral margin; front view with the median lines and nodules of valves approximate and within the margin. The frustules are mostly very thin, hyaline, and imperfectly siliceous: their form is peculiar; and Professor Arnott, who has given in the sixth volume of the 'Microscopic Journal' a detailed account of their structure, aptly compares it to that of " a coffee-bean rounded on the back and hollowed out in front." Many of the species are insufficiently known; they should be viewed in front, back, and side. Fortunately, from their hyaline nature, the dorsum and venter can in most cases be examined merely by the alteration of the focus. The lateral view closely resembles that of a Cymbella, but has the nodule marginal. The front view is usually barrel-shaped, owing to the convexity of the valves, which are so curved inwards that their central nodules are more or less approximate and frequently appear nearer to the connecting zone than to the margins. The portions of the valves interior to the median line are inconspicuous, and rarely afford diagnostic aid; whilst the portions exterior to the median lines are important, offer the best view of the transverse striæ, and vary in shape according as the median line appears straight, concave, or flexed. In our descriptions we call these latter the outer portions, and when they project inwards at the centre in a cuneate manner, or appear inflexed, we term them canoe-shaped. The dorsum is convex, shows no nodules or lateral valves, and is mostly marked by longitudinal lines between longitudinal series of short, transverse striæ, like the connecting zone of Striatella, but unaccompanied by internal plates. The late Professor Gregory, who directed attention to these facts, believed that Amphora could be divided into two groups—*simple* and *complex*, from the absence or presence of this structure. His arrangement, however, we are unable to adopt, because in many species a decision is difficult; and indeed we think that the longitudinal lines, so common if not invariable, indicate the complex structure, although the hyaline nature of the frustules may interfere with its detection. In Amphora the specific characters are taken, almost constantly, from the front view, and not from the lateral one as in most other genera of Diatomaceæ; and as the connecting zone varies greatly in breadth according to the condition of the frustule, due allowance must be made for that fact. If division has recently taken place, the connecting zone will be narrow, and the ends of the frustule less broadly truncate than just previous to that process. For the same reason we believe that the number of longitudinal lines varies and affords no aid in distinguishing the species. Amphora contains several species of Agardh's genus Cymbella, and ought, in our opinion, to have retained that generic appellation. Because of its cymbiform frustules, we have removed this genus from the Naviculeæ, where Kützing placed it; the same reason, added to the presence of median lines and nodules, compels us to place it with the Cymbelleæ instead of with the Surirelleæ, as Rabenhorst has done.

* *Frustules in front view distinctly constricted at the middle.*

Amphora *binodis* (Greg.).—Frustules constricted at the middle; lobes inflated at the base, with broadly linear, subtruncate ends; transverse striæ obscure, about 30 in ·001″. GDC. p. 38, pl. 4. f. 67. Marine. Scotland. Resembles the next species, but is smaller, with more rounded inflations and obscure striæ, Greg.

A. *angularis* (Greg.).—Frustules sinuato-constricted at the middle; lobes angularly inflated, with short, broadly linear, truncate, produced ends; striæ distinct. Greg. MJ. iii. p. 39, pl. 4. f. 6. (vii. 50.) Differs from *A. binodis* by having angular inflations and coarser striæ.

A. *lyrata* (Greg.). — Frustules constricted at the middle; lobes with inflated base and truncate end; nodules transversely dilated; striæ distinct. GDC. p. 48, pl. 5. f. 82. Marine. Scotland. Striæ about 36 in ·001″; connecting zone with longitudinal lines.

A. *Milesiana* (Greg.). — Frustules linear, with slightly constricted middle and truncate ends, furnished with longitudinal lines and conspicuous transverse striæ. GDC. p. 49, pl. 5. f. 83. Scotland. Striæ about 28 in ·001″, Greg.

2* *Frustules not panduriform; nodules transversely dilated and bar-like.*

A. *membranacea* (S.).—Frustules elliptic-oblong, with rounded ends; valves with a central transverse band, and very close transverse striæ; connecting zone with longitudinal lines. SBD. i. p. 20, pl. 2. f. 29; Ro MJ. vi. p. 24, pl. 3. f. 8. Brackish water. Europe. (vii. 51.) Scarcely silicious.

A. *lævissima* (Greg.).—Frustules very hyaline, linear-oblong, with rounded ends; outer portions of valves slender, tapering, with a transverse nodule, and obsolete or indistinct striæ. GDC. p. 41, pl. 4. f. 72. Scotland.

A. *lævis* (Greg.).—Frustules very hyaline, linear, with subtruncate ends; outer portions of valves very narrow, with a transverse nodule and indistinct striæ. GDC. p. 42, pl. 4. f. 74. Scotland. Outer portion of valve canoe-shaped; striæ about 60 in ·001″.

A. *minutissima* (S.).—Frustules parasitic, very minute, oval or suborbicular, with transversely dilated nodules, and 64 obscure striæ in ·001″. SBD. i. p. 20, pl. 2. f. 30. Fresh water. Parasitic on other Diatomaceæ.

A. *rimosa* (E.).—Germany. Frustules elliptic-oblong, with rounded ends, narrow lunate outer portions, transverse nodules, and no striæ. EM. pl. 13. 2. f. 17.

A. *elegans* (Greg.). — Frustules oval, with truncate ends; outer portion of valves lunate, with transverse nodule, and very fine, inconspicuous, transverse striæ. Greg. TM. v. p. 70, pl. 1. f. 30. Scotland.

A. *ostrearia* (Bréb.).—Frustules hyaline, elliptic-oblong, with rounded ends; outer portion of valves narrow, canoe-shaped, with transverse nodule and distinct striæ; dorsum with numerous, very delicate longitudinal lines. Bréb. in KSA. p. 94. Marine. France. Lateral view lunate, with convex dorsum and straight venter.

A. *quadrata* (Bréb.).—Frustules hyaline, quadrangular, with truncate ends; outer portion of valve small, inflexed, with transverse nodule; dorsum with numerous, very delicate longitudinal lines. KSA. p. 95. Marine. France. Lateral view very narrow, lunate. *A. quadrata* differs from *A. ostrearia* by its straight margins and truncate ends.

A. *rectangularis* (Greg.). — Frustules narrow, linear, with truncate ends; valves with a transverse nodule, and 40 fine transverse striæ in ·001″. Greg. TM. v. p. 70, pl. 1. f. 29. Scotland.

A. *nobilis* (Greg.). — Frustules very hyaline, barrel-shaped, with truncate ends; outer portion of valves very narrow, arcuate, with transverse nodule, and fine transverse striæ; dorsum with longitudinal lines. GDC. p. 49, pl. 5. f. 87. Scotland. Large; striæ about 40 in ·001″; ventral margin of valves concave.

A. *acuta* (Greg.). — Frustules elliptic, with truncate ends; outer portion of valves arcuate, with straight median line, transverse nodule, and distinctly moniliform, transverse striæ. GDC. p. 52, pl. 5, 6. f. 93. Scotland. Large; striæ about 36 in ·001″.

A. *litoralis* (Donkin).—Frustules oval, with truncate ends; outer compartment canoe-shaped, with distinct moniliform striæ and transverse bar-like nodule; dorsum with longitudinal series of short transverse striæ. Donkin in TMS. vi. p. 30, pl. 3. f. 15. Marine. Northumberland. (VII. 52.)

3* *Frustules with produced or rostrate ends and roundish nodules.*

A. *aponina* (K.).—Frustules lanceolate-elliptic, with produced, truncate apices, and no longitudinal lines. KB. p. 108, pl. 5. f. 33. Italy. Minute. 1-1080″ to 1-650″.

A. *coffeæformis* (Ag., K.).—Frustules lanceolate, with produced, obtuse apices, strong marginal longitudinal lines, and faint or obsolete median ones. KB. p. 108, t. 5. f. 37. = *Frustulia coffeæformis*, Ag.; *Navicula quadricostata*, E Inf. t. 21. f. 9. *β. Fischeri*, with fewer marginal and obsolete median longitudinal lines. Carlsbad. 1-1720″ to 1-480″.

A. *acutiuscula* (K.).—Frustules turgid-lanceolate, with acuminated, subacute apices, and strong marginal longitudinal lines. KB. p. 108, t. 5. f. 32. Marine. Genoa. Small. 1-576″.

A. *lineata* (Greg.).—Frustules elliptic-lanceolate, with prolonged conic ends and conspicuous longitudinal lines; transverse striæ fine, obscure, about 42 in ·001″. GDC. p. 40, pl. 4. f. 70. Scotland. Outer portions of valves narrow lunate, with convex dorsum and straight venter.

A. *Ergadensis* (Greg.). — Frustules elongated lanceolate, with broad, slightly produced, truncate ends; transverse striæ conspicuous, about 24 in ·001″. GDC. p. 40, pl. 4. f. 71. Scotland. Remarkable for its length. Outer portions of valves slender, with nearly straight venter.

A. *exigua* (Greg.).—Frustules elliptic-lanceolate, with slightly produced, obtuse ends; transverse striæ about 28 in ·001″. GDC. p. 42, pl. 4. f. 75. Scotland. Small; in size and form it approaches nearest to *A. lineata*, but its markings are totally different, Greg.

A. *Semen*, EM. pl. 38. 17. f. 10. Iceland. In the figure, this species is ventricose, with broad, shortly produced, truncate ends, and without striæ.

A. *salina* (S.).—Frustules elliptic-oblong, with slightly produced, truncate extremities; valves lunate, rostrate, with 64 striæ in ·001″. SBD. i. p. 19, pl. 30. f. 251. Brackish water. Sussex. Scarcely silicious. ·0008″ to ·0016″, S.

A. *turgida* (Greg.).—Frustules broadly elliptic or suborbicular, with short rostrate apices; outer portions semilunate, with capitate apices, and 24 rather coarse radiant striæ in ·001″. GDC. p. 38, pl. 4. f. 63. Scotland. Small.

A. *monilifera* (Greg.). — Frustules elliptic-oblong, with short, broad, rostrate ends; outer portions arcuate, with capitate, recurved apices; dorsum with converging longitudinal rows of distant dots. GDC. p. 39, pl. 4. f. 69. Scotland.

A. *cymbifera* (Greg.).—Frustules inflated, with short, subcapitate, rostrate apices; outer portions arcuate, with capitate, recurved ends, and 22 rather coarse transverse striæ in ·001″; connecting zone with converging longitudinal bars. GDC. p. 54, pl. 6. f. 97. Scotland. (VII. 54.) Large; dorsum furnished with longitudinal series of transverse striæ, separated by longitudinal lines or bars.

A. *proboscidea* (G.).—Frustules linear-oblong, with produced, truncate extremities; valves arcuate, with rostrate, capitate ends, and 20 coarse transverse striæ in ·001″; dorsum with longitudinal series of transverse striæ. GDC. p. 54, pl. 6. f. 98. Scotland. Large. The capitate beaks of the valves are longer than in *A. cymbifera*, and are not recurved, but bent forwards.

A. *costata* (S.).—Frustules ventricose, with short, broad, truncate beaks, longitudinally costate; costæ with a double line of moniliform puncta. SBD. i. p. 20, pl. 30. f. 253. Marine. Britain. Valves semilunate, with capitate ends; transverse striæ coarse, about 16 in ·001″, Greg.

A. *Terroris* (E.).—Valves elongated, straight, semilunate, suddenly attenuated into stiliform beaks; transverse striæ strongly granulated, 19 in 1-1200″. ERBA. 1853, p. 526; EM. pl. 35 A. 23. f. 2. Akin to *A. fasciata*, but smaller and more strongly granulate, E.

A. *macilenta* (Greg.).—Frustules narrow elliptic-lanceolate, with short, broad, slightly produced apices; outer portion of valves with straight ventral margin, and about 30, rather coarse parallel striæ in ·001″. GDC. p. 38, pl. 4. f. 65. Scotland.

A. *granulata* (Greg.). — Frustules linear-oblong or elliptic-oblong, with short, broad, truncate, slightly produced apices; outer portion of valve with straight ventral margin, rostrate apices, and from 24 to 30 transverse striæ in ·001″; dorsum having longitudinal lines alternating with series of granules. GDC. p. 53, pl. 6. f. 96. Scotland.

A. *ventricosa* (Greg.).—Frustules lanceolate, with turgid middle and tapering obtuse ends; outer portions slender, arcuate, with slightly concave venter, acute ends, and about 22 conspicuous transverse striæ in ·001″. GDC. p. 39, pl. 4. f. 68. Scotland.

4* *Frustules neither constricted at the middle nor rostrate at the ends; nodules roundish.*

A. *ovalis* (K.).—Frustules turgid, oval, with broadly rounded or truncate ends; outer portion of valves canoe-shaped, with 24 distinct moniliform striæ in ·001″; connecting zone with very fine longitudinal lines. KB. p. 107, t. 5. f. 35, 39. = *Navicula Amphora*, E Inf. t. 14. f. 3. Fresh water, frequent. Europe, Africa. (VII. 56; IX. 153.) Large. 1-456″ to 1-120″.

A. *Libyca* (E.).—Frustules oval, with with broadly rounded or truncate ends; lateral view semilunate, with very convex dorsum, obtuse ends, and slightly concave venter. EA. t. 3. 1. f. 42; EM. many figures. Apparently the most common species, since Ehrenberg gives upwards of 100 habitats for it in Europe, Asia, Africa, and America. Lough Mourne deposit. (XII. 38.) We are unable to distinguish this form from *A. ovalis*, and probably these have been confounded; we believe they are in SBD., because there no species but *A. ovalis* is noticed as occurring in the Lough Mourne deposit, whilst Ehrenberg only mentions this species as found in it. Ehrenberg's figures and description do not enable us to decide; for the latter is too indefinite, and the former vary so much as apparently to belong to more than one species. Almost the only characters the figures have in common are the oval form and striated valves. The median line is either concave, straight, or produced at the nodule; and the connecting zone is figured sometimes smooth, and sometimes with longitudinal lines.

A. *pellucida* (Greg.).—Frustules very hyaline, oval, with broadly rounded ends; outer portions of valves canoe-shaped, with about 30 very delicate striæ in ·001″. GDC. p. 41, pl. 4. f. 73. Scotland. Resembles *A. ovalis* in form, but differs in its marine habitat, very hyaline aspect, and singular delicacy of the striæ. The latter characters distinguish it also from *A. incurva*, Greg.

A. *truncata* (Greg.).—Frustules barrel-shaped, with truncate ends; outer portions of valves canoe-shaped, striated; dorsum with longitudinal series of short transverse striæ. GDC. p. 43, pl. 5. f. 77. Scotland. Large.

A. *lineolata* (E.).—Frustules turgid, elliptic-oblong, with truncate apices, strong longitudinal marginal lines, and very fine ones in the connecting zone. E Inf. t. 14. f. 14; EM. pl. 13. 1. f. 19; Rab D. pl. 9. f. 9, 10. Fresh water. Europe, Africa, America. 1-480″ to 1-140″. The figures referred to represent the frustule as large, barrel-shaped, with canoe-shaped outer portions.

A. *Gregorii*.—Frustules barrel-shaped; outer portions canoe-shaped, with about 34 transverse striæ in ·001″; dorsum with longitudinal series of short transverse striæ. = *A. quadrata*, GDC. p. 49, pl. 5. f. 85. Scotland. Ends truncate.

A. *Grevilliana* (Greg.). — Frustules broad, linear, oblong or barrel-shaped; outer portions canoe-shaped, with from 28 to 34 distinct, moniliform transverse striæ in ·001″; dorsum with longitudinal series of transverse striæ. GTM. v. pl. 1. f. 36; GDC. p. 50, pl. 5. f. 89. = *A. complexa*, GDC. p. 51, pl. 5. f. 90; *A. fasciata*, GDC. p. 51, pl. 5. f. 91. Scotland. Large; ends truncate.

A. *sulcata* (Bréb.).—Frustules hyaline, oblong or elliptic-oblong, with truncate ends; outer portions canoe-shaped, with 38 transverse striæ in ·001″; dorsum with longitudinal series of transverse striæ. BD. pl. 18. f. 8; GDC. p. 51, pl. 5. f. 92. France, Britain. Large; differs from *A. costata* in its not produced but truncate apices, Bréb.

A. *robusta* (Greg.).—Frustules broadly oval, with rounded ends and canoe-shaped outer portions; transverse striæ distinct, moniliform, 16 in ·001″. GDC. p. 44, pl. 5. f. 79. Scotland. Large; conspicuous from its size and stoutness.

A. *Proteus* (Greg.).—Frustules barrel-shaped or oblong; outer portions canoe-shaped, with 22 finely moniliform transverse striæ in ·001″. GDC. p. 46, pl. 5. f. 81. Scotland. Large, with truncate apices. Varies much in form and length.

A. *Arcus* (Greg.).—Frustules barrel-shaped; outer portions narrow, canoe-shaped, with 16 to 18 coarsely moniliform striæ in ·001″; dorsum with longitudinal series of moniliform transverse striæ. GMJ. iii. pl. 4. f. 4; TM. v. pl. 1. f. 37; GDC. p. 50, pl. 5. f. 88. Scotland. Large, with truncate ends. The frustule has the form of a barrel, with ribs and bars. It is distinguished from *A. Grevilliana* by its coarsely moniliform striæ. Detached segments resemble in form a strung bow with rostrate apices.

A. *veneta* (K.). — Frustules minute, elliptic-oblong, with truncate ends; lateral view semielliptic. KB. p. 108, t. 3. f. 25. Marine. Venice and Constantinople.

A. *borealis* (K.).—Frustules minute, oblong-lanceolate, with acute or truncate apices; lateral view semilanceolate. KB. p. 108, pl. 3. f. 18. Heligoland. 1-1200″.

A. *Hohenackeri* (Rab.). — Frustules minute, oblong or oblong-lanceolate, with three longitudinal lines on each side. Rab D. p. 31, pl. 9. f. 11. South Persia.

A. *hyalina* (K.).—Frustules hyaline, elliptic-lanceolate, with acute or truncate apices, and a few, very delicate longitudinal lines; transverse striæ obscure. KB. p. 108, pl. 30. f. 18; SBD. i. p. 19, pl. 2. f. 28. Marine. Europe. (vii. 58.) Imperfectly silicious. 1-600″ to 1-422″.

A. *nana* (Greg.). — Frustules small, narrow elliptic-oblong, with rounded ends; outer portions with straight ventral margin, and about 50 transverse striæ in ·001″. GDC. p. 38, pl. 4. f. 64. Scotland.

A. *elliptica* (Ag., K.). — Frustules small, elliptic-lanceolate, turgid at the middle, with attenuated obtuse apices; valves distinctly striated. KB. p. 108, t. 5. f. 31. = *Cymbella elliptica*, AD. p. 8. Marine. Baltic. Associated in amorphous mucus, K.

A. *navicularis* (E.).—Frustules elliptic-lanceolate, with subacute ends and conspicuous transverse striæ. EA. p. 122, t. 1. 1. f. 12. Africa, America. (xii. 37.)

A. *gracilis* (E.).—Frustules small, narrow oblong, truncate; valves slender, transversely striated. EA. t. 3. 1. f. 43; EM. t. 37. 3. f. 1. Europe, Asia, Africa, America, Australia. (xii. 26.) Outer portion of valve lunate.

A. *affinis* (K.). — Frustules oblong, slightly attenuated, with rounded or broadly truncate apices, marked with longitudinal lines, the central ones very faint. KB. p. 107, t. 30. f. 66. France, Britain. 1-960″ to 1-390″.

A. *marina* (S.).—Frustules elliptic, with somewhat truncate extremities; nodule very faint; striæ 40 in ·001″. ANH. 1857, xix. p. 7, pl. 1. f. 2. Marine. France, Britain. ·0006″ to ·0024″. (vii. 59.) Not unfrequent, but has been overlooked from its exact resemblance in outline to *A. affinis*; it may be known by its more delicate striæ and inconspicuous nodules, Sm.

A. *dubia* (Greg.).—Frustules oblong, with broadly rounded ends; outer portions stout, with concave venter, obtuse ends, and 24 fine transverse striæ in ·001″. GDC. p. 42, pl. 5. f. 76. Scotland. It has some analogy with *A. marina*; but the striation is coarser, and nodules distinct, Greg.

A. *oblonga* (Greg.).—Frustules elongated linear-oblong or elliptic-oblong, with conic apices; outer portions very narrow, canoe-shaped, with conspicuous nodule, and 24 distinct transverse striæ in ·001″. GDC. p. 43, pl. 5. f. 78. Scotland. Large.

A. *elongata* (Greg.).—Frustules elongated, narrow, oblong-lanceolate, truncate; outer portions very narrow, canoe-shaped, with 26 conspicuous transverse striæ in ·001″; dorsum with longitudinal lines. GDC. p. 49, pl. 5. f. 84. Scotland. Large.

A. *angusta* (Greg.). — Frustules narrow linear-oblong, truncate; outer portions with 44 fine transverse striæ in ·001″. GDC. p. 38, pl. 4. f. 66. Scotland.

A. *obtusa* (Greg.). — Frustules broad linear-oblong, with broadly rounded ends; outer portions canoe-shaped, with 70 very fine transverse striæ in ·001″. Greg. TM. v. pl. 1. f. 34. Scotland. Large.

A. *plicata* (Greg.).—Frustules hyaline, broad linear-oblong, with rounded angles and truncate apices; outer portion canoe-shaped, very faintly striated; dorsum with longitudinal lines. Greg. TM. v. pl. 1. f. 31. Scotland. Large. The longitudinal lines give a plicate appearance to the frustule, Greg.

A. *crassa* (Greg.).—Frustules linear or linear-oblong, with rounded or subtruncate apices; outer portions canoe-shaped, with from 12 to 20 coarse transverse striæ in ·001″; dorsum with longitudinal series of transverse striæ. GDC. p. 52, pl. 6. f. 94. = *A. sulcata*, Ro. MJ. vi. p. 18, pl. 3. f. 7 ?. Britain. Large.

A. *spectabilis* (Greg.). — Frustules broad linear or linear-oblong, with rounded angles and subtruncate apices; outer portions canoe-shaped, with 14 to 16 distinct transverse striæ in ·001″; dorsum with longitudinal series of transverse striæ. GDC. p. 44, pl. 5. f. 80. Scotland. (vii. 57.) Large.

A. *excisa* (Greg.).—Frustules hyaline, broadly linear or linear-oblong, truncate; appearing notched at the sides from the marginal position of the nodules; outer portion canoe-shaped, with 52 very fine transverse striæ in ·001″; dorsum with longitudinal series of short striæ. GDC. p. 49, pl. 5. f. 86. Scotland.

A. *arenaria* (Donkin).—Frustules hyaline, broadly linear, with rounded angles and slightly gibbous middle; outer compartment of valves canoe-shaped; dorsum faintly marked with longitudinal lines. Donkin, TMS. vi. p. 31, pl. 3. f. 16. Marine. Northumberland. Large; transverse striæ obscure.

A. *amphioxys* (Bailey). — Frustules linear, with subtruncate apices; lateral view arcuate, finely striated, with convex dorsum, concave venter, and rostellate recurved extremities. BMO. p. 39, pl. 2. f. 20-22. United States. The side view bears a striking resemblance to *Eunotia amphioxys*, Bailey.

A. *biseriata* (Greg.).—Frustules elongated linear, with rounded apices; median line marginal, except at the centre, where it curves inwards; dorsum with longitudinal series of coarse transverse striæ. Greg. TM. v. p. 71, pl. 1. f. 32. Scotland. Large.

A. *tenera* (S.). — Frustules narrow linear, with rounded or truncate ends; valve longitudinally rugose; striæ obscure, 62 in ·001″. SBD. i. p. 20, pl. 30. f. 252. Marine. England. Scarcely silicious. Professor Smith regarded this species as the *A. lineolata*, E.,—an opinion in which we are unable to concur, since its narrow-linear form is very unlike the broad inflated figure of the latter, and could never be described as turgid.

A. *bacillaris* (Greg.).—Frustules narrow linear, with slightly attenuated, obtuse ends, outer portions very narrow, arcuate, finely striated; dorsum with longitudinal series of granules. GDC. p. 55, pl. 6. f. 100. Scotland. Distinguished from *A. pusilla* by its finer striæ and granules, Greg.

A. *pusilla* (Greg.).—Frustules narrow linear, with subtruncate apices; outer portions very narrow, canoe-shaped, with 24 conspicuous striæ in ·001″; dorsum with longitudinal series of granules or short striæ. GDC. p. 53, pl. 6. f. 95. Scotland.

A. *Erebi* (E.).—Lateral view arcuate, with obtuse apices, concave venter, and about 25 very fine striæ in 1-1200″. ERBA. 1853, p. 526; EM. pl. 35 A. 23. f. 3. Assistance Bay, North Pole.

A. *crystallina* (E.).—Frustules smooth, crystalline, with convex dorsum, concave venter, and broadly truncate ends. ERBA. 1840, p. 10. Tjorn. 1-432″.

A. *fasciata* (E.).—Frustules with convex dorsum, plane venter, broadly truncate ends, and longitudinal series of closely set, fine striæ. ERBA. 1840, p. 11. Tjorn. 1-456″.

A. *carinata* (E.). — Frustules large, navicular, with plane sides, acute apices, and four lateral striated fasciæ. ERBA. 1840, p. 10. Island of Tjorn. 1-240″.

A. *Atomus* (E.). — Very minute, on one side elliptic with rounded ends, on the other linear and truncate. 1-2640″.

A. *Ægæa* (E.).—Frustules navicular, oblong, truncate, with 10 punctated longitudinal lines, oblong umbilici, and curved lines; the space between the umbilici with two straight lines curved at each end. ERBA. 1858, p. 13. Ægean Sea.

A. *stauroptera* (Bailey). — Frustules elliptical, elongated, with striated margins; central portions crossed, as in Stauroptera, by a broad band. BC. vii. p. 8, f. 14, 15. Halifax, Nova Scotia. The figure is elongated, acutely lanceolate, and the nodules connected by a transverse central depression.

Species, the descriptions of which are unknown to us.

A. *cymbiformis*, EM. pl. 16. 1. f. 43. Lateral view semilunate, with convex dorsum, straight venter, obtuse apices, diverging striæ, and submarginal sutural line and nodule.

A. *gigas*, EM. pl. 6. 2. f. 13. North Africa. Figure imperfect, large, oval, transversely striated; connecting zone with faint longitudinal lines.

A. *incurva*, Greg. MJ. iii. pl. 4. f. 5. Scotland. Lateral portion canoe-shaped and finely striated.

A. *paradoxa* (E.), A. *vulgaris* (E.), Asia; *A. Nilotica* (E.), River Nile; *A. ocellata* (E.), Florida.

Genus RHIZONOTIA (E.).—Frustules with two median nodules (with the character and form of Amphora), but by longitudinal division often becoming a mass united together in a longitudinal series by a progeny of stolons or silicious radicles. This form is adnate on Confervæ, and has many fine longitudinal striæ, which appear somewhat rough or granular. The frustule is very crystalline and transparent. It has internally pale-green, almost colourless ova, E.

RHIZONOTIA *Melo* (E.).—The lateral connecting portions of the progeny in self-division mostly forked, 3 to 10. ERBA. 1843, p. 139. = *Rhizosolenia Melo*, EM. pl. 35. 6. f. 14, 15 ?. Swan, Avon, and Canning Rivers in Western Australia. (VIII. 41.)

FAMILY XVII.—GOMPHONEMEÆ.

Frustules in front view cuneate, laterally attenuated at the base, with a median longitudinal line and a central nodule. Mostly aquatic. The Gomphonemeæ differ from the Meridieæ and the Licmophoreæ, and the cuneate species of Surirella, by the median longitudinal line and the central nodule. The cuneate form in the front view distinguishes it from the rest of the Diatomaceæ.

Genus SPHENELLA (K.).—Frustules in front view cuneate, free, neither stipitate, affixed, nor enclosed in a common gelatinous substance. Aquatic. "The Sphenellæ only differ from Naviculæ in their cuneate form, perfectly similar to that of Meridion, by which, too, the associations (*S. angustata*) become flabelliform and quasi-circular; but they differ by the central nodule of the lateral surfaces. Hence there remains a greater similitude to the Naviculæ; and the distinctive characters are so slight, that the generic characters of at least two species remain uncertain" (Menegh. p. 411).

SPHENELLA *glacialis* (K.).—Minute; lateral view lanceolate, with subacute ends and very delicate transverse striæ. KB. p. 83, pl 3. f. 16. Monte Rosa, Alps. 1-1320".

S. *parvula* (K.).—Minute; lateral view lanceolate, with produced ends, the base subdilated. KB. p. 83, pl. 30. f. 63. France. 1-960". Striæ indistinct. It cannot be distinguished from a Navicula, except on a front view.

S. *angustata* (K.).—Minute, flabellately conjoined, narrow linear, cuneate, lateral view lanceolate, with obtuse ends. KB. p. 83, pl. 8. f. 4. Germany, France. (XIV. 30.) 1-960".

S. *vulgaris* (K.).—Small; lateral view finely striated, dilated at the middle, and tapering to the stout beak-like ends. KB. p. 83, pl. 7. f. 12. Germany, France. 1-1020".

S. *obtusata* (K.). — Small; lateral view smooth, dilated above the middle, with rounded obtuse apices. KB. p. 83. pl. 9. f. 1. Prussia. (XIV. 31.) 1-900". Lateral view clavate-lanceolate.

S. *rostellata* (K.).—Solitary, smooth, broadly cuneate; lateral view dilated at the middle, acuminate at each end. KB. p. 83, pl. 9. f. 3. β. *elongata*, larger, with produced, obtuse apices. France. 1-1820" to 1-336".

S.? *Italica* (K.).—Broadly cuneate; lateral view obovate, slightly dilated at the middle, and with a transverse median nodule. KSA. p. 63. = *Gomphonema Italicum*, KB. t. 30, f. 75.

Genus GOMPHONEMA (Ag.).—Frustules affixed at the base or stipitate; in front view cuneate; laterally attenuated below, with a median longitudinal line and central nodule. "As Cocconema from Cymbella, so Gomphonema only differs from Sphenella by the stipes, on which account species are now referred to Gomphonema which formerly belonged to Sphenella. . . . Kützing supposes the Gomphonemæ to be at first free, like Sphenella, and that afterwards they affix themselves. . . . No direct observation confirms this hypothesis; and it is at least as just to admit the other, that the Sphenellæ are at first attached like the Gomphonemæ and afterwards become free. Ehrenberg says that the Gomphonemæ can become free and again adhere" (Menegh. p. 412). The descriptions apply to the lateral view, unless otherwise stated.

* *Frustules in lateral view constricted beneath the apex, appearing urn-shaped.*

† Lateral view with the head apiculate or acute.

GOMPHONEMA *coronatum* (E.).—Slender, with ventricose middle, obcordate apiculate head, and lanceolate base; front view crested at apex. EM. pl. 6. 1. f. 33. = *G. acuminatum β*, SBD. i. p. 79, pl. 28. f. 238 β. Europe, America, Asia, Australia. (XIV. 36.) *G. coronatum* is distinguished from the allied forms by its inflated basal portion; but the lower inflation is sometimes very obscure, and we believe Professor Smith was justified in regarding this form as a mere variety of *G. acuminatum*. 1-480″.

G. *laticeps* (E.).—Habit of *G. coronatum*, but shorter, and head wider than the central inflation. EM. pl. 5. 1. f. 34. America, Asia. Ehrenberg's figures have the basal portion linear, not inflated. He gives about fifteen habitats.

G. *Sceptrum* (Rab.).—Habit of *G. coronatum*, but larger and more robust, the middle more inflated and much broader than the obcordate apiculated head; base stalk-like, not inflated. RabD. p. 60, pl. 8. f. 8. America.

G. *acuminatum* (E.).—Slender, tapering below into the stalk-like base, constricted above the ventricose middle; head dilated, acuminate. SBD. i. p. 79, pl. 28. f. 238. = *G. trigonocephalum*, EM. pl. 6. 1. f. 36; *G. appendiculata*, Perty KL. p. 204, t. 17. f. 12. Europe, Asia, Africa, America, and Australia. (XIII. 23.) Differs from the foregoing species by a cuneate or tapering apex. In a variety figured by Professor Smith the constriction is nearly obsolete. 1-860″ to 1-430″.

G. *Brébissonii* (K.).—Slender, narrow, with a longly attenuated base and a slightly ventricose middle, separated by a slight constriction from the cuneate, attenuated, somewhat obtuse head. KSA. p. 66. France. Stipes abbreviated or nearly obsolete. Akin to *G. acuminatum*, but more slender, more elongated into the stipes-like base, and head and median inflation smaller.

G. *Americanum* (E.).—Lateral view with three inflations, separated by two constrictions; head ovate, subacute. EM. several figures. America, Iceland. 1-864″.

G. *elongatum* (S.).—Lateral view with three inflations, the median one greatest; upper one oblong, with cuneate apex; lower slender, slight. S. in ANH. 2 ser. xv. p. 6, pl. 1. f. 4. = *G. Brébissonii*, Greg. MJ. ii. pl. 4. f. 18. France, England. 1-864″. Scarcely distinct from *G. Americanum*; both have the inflated base of *G. coronatum*, and cuneate head of *G. acuminatum*.

2 † Head rounded, neither acute nor apiculate.

G. *geminatum* (A.).—Frustules very large, in front view cuneate, their terminal puncta obsolete; lateral view inflated at the middle, constricted above and below, with dilated, rounded ends; striæ distinctly moniliform. SBD. p. 78, pl. 27. f. 235. = *Diomphala Clava Herculis*, EM. pl. 15 A. f. 93. (VII. 60.) On rocks in subalpine streams. Europe. This species forms large spongy cushion-like tufts composed of densely matted filaments. The frustules are easily recognized by their large size, the absence of terminal puncta in the front view, and the conspicuous striæ of their lateral valves. The neck is much constricted, and the large head broadly rounded at the end. Kützing refers *G. Herculeanum* (E.) to this species, but, we believe, erroneously.

G. *capitatum* (E.).—Lateral view turgid at the middle and slightly constricted beneath the broadly rounded head; puncta in front view evident. SBD. p. 80, pl. 28. f. 237. = *G. turgidum*, EM. pl. 2. 2. f. 40? Europe, Asia. 1-1720″ to 1-280″. Striated, attenuated at its base; stipes elongated, dichotomous. Sometimes the constriction, which is less marked than that of the next species, is nearly obsolete, and the frustules in the lateral view are obovate.

G. *constrictum* (E.).—Lateral view ventricose at the middle, with a short neck and broadly rounded head; puncta at upper end of front view very evident. SBD. pl. 28. f. 236. = *G. truncatum*, EM. many figures; *G. paradoxum*, EM. pl. 9. 1. f. 33, 34; *G. pohliæforme*, K., Ralfs. Forms a brown discoloration on aquatic plants. Common. (X. 187–190.) 1-1720″ to 1-280″; striated, attenuated at its base; stipes becoming elongated and branched. Distinguished from *G. geminatum* by its much smaller size and distinct puncta in front view. We find this species very variable in the development of its neck; and sometimes in a young state the constriction is but slight, and the form resembles *G. capitatum*.

G. *subtile* (E.).—Slender, lateral view twice constricted; head small, obtuse; neck slender, elongated. EM. several figures. Asia, Africa, America, Lough

Mourne deposit. It differs from *G. constrictum* in its more slender form and longer neck.

G. *Anglicum* (E.).—Twice constricted; head rounded, rather narrower than the oblong inflated middle, which tapers below into a linear stipes-like base. EM. pl. 15 A. f. 86. Lough Mourne deposit, Ireland. It is allied to *G. subtile*. Probably both forms should be united to *G. constrictum*.

G. *Mustela*, EM. pl. 17. 2. f. 37. Fossil, Finland, France; recent, Berlin. We have seen no description of this species. Ehrenberg's figures represent the lateral view elongated, with an oblong median inflation, tapering below into a linear stipes-like base, and above into the oblong head, which is rounded at the apex.

2* *Frustules imbedded in a shapeless gelatinous substance.* (Gomphonella, *Rab.*)

G. *olivaceum* (Lyngb., E.).—Frustules and stipes forming a gelatinous mass; front view broadly cuneate, with conspicuous terminal puncta; lateral valves obovate or subclavate, distinctly striated. SBD. pl. 29. f. 244. = *Gomphonella olivaceum*, Rab., *β. angusta*; *G. angusta*, K.; *G. angusta*, Rab D. p. 61, t. 9. f. 2. Smaller and shorter, with obsolete striæ. Europe. 1-2300" to 1-1020". It forms rather large mucous masses of a pale brown colour, which, when dried, become pale green with a granulated appearance.

G. *Lenormandi* (Chauvin). — Front view narrow, nearly linear; lateral valves lanceolate acute, with indistinct striæ. KSA. p. 65. = *Sphenella? Lenormandi*, KB. pl. 30. f. 61; *Gomphonella Lenormandi*, Rab. Falaise, France. 1-960". Stipes slender, at length elongated.

G. *parvulum* (K.). — Frustules of the size and form of *Sphenella parvula*, but stipitate and aggregated into a dense mucous stratum. KSA. p. 65. = *Gomphonella parvula*, Rab.

3* *Frustules in front view curved, with two longitudinal suture-like lines or vittæ.*

G. *curvatum* (K.).—Frustules in front view curved, with distinct terminal puncta and longitudinal vittæ; lateral valves clavate. KB. p. 85, pl. 8. f. 1-3. = *G. minutissimum*, E. Common. Europe, Asia, Africa, America. (XII. 9-12; XIII. 11.) *α*, aquatic, = *G. curvatum*, SBD.; *β*, marine, = *G. marinum*, SBD. This species differs considerably from the other species of Gomphonema in its curved frustules and longitudinal suture-like striæ, and perhaps ought to be separated from them. It agrees with Rhipidophora in the latter character and with Achnanthes in having a median nodule in the ventral or concave valve only. It varies in its mode of growth, according as it is found in fresh, brackish, saline, or marine waters. The frustules are scattered, flabellately conjoined, or aggregated in minute cushion-like tufts. The stipes is short, incrassated, and irregularly branched, or more or less elongated, slender, and dichotomously divided. Professor Smith makes the marine form a distinct species, and gives the following differential characters:—*G. curvatum*: "Stipes elongated, filamentous and dichotomous; striæ 22 to 30 in ·001'"; aquatic." *G. marinum*: "Stipes incrassated, branching in an irregular manner; striæ 35 in ·001'"; marine." Professor Smith, however, admits that it is difficult to distinguish them if we confine our attention merely to the frustules; "but," continues he, "the general appearance of the growing plants, arising from the characters of their stipes, is very different, and their habitats are so wide apart that there can be no doubt of their distinctness." We are unable to concur in this opinion; for our experience is quite different, and, as we stated several years ago, we find the stipes in the marine form more elongated than in the aquatic one. "I have attempted in vain to find some specific character to distinguish the marine form. It is more branched, has a rigid appearance, and the striæ connecting the puncta on the front surface are strongly marked; but intermediate specimens occasionally occur, in which all these differences vanish" (ANH. xii.).

4* *Frustules in lateral view obovate or clavate.*

† Crested or pointed at the apex.

G. *cristatum* (Ra.).—Front view crested; lateral view obovate, crowned with a minute point. SBD. p. 79, pl. 28. f. 239. = *G. nasutum*, EM. pl. 2. 2. f. 41; *Sphenella? appendiculata*, Perty, p. 203, t. 17. f. 14. Europe, Asia, America. Stipes nearly simple; frustules in front view cuneate, with somewhat rounded angles, crested as in *G. coronatum*; terminal puncta obsolete. Ehrenberg describes his *G. nasutum* as allied to *G. Augur*, but shorter and stouter. To *G. cristatum* probably belongs the Mexican form described by Ehrenberg as a variety of *G. Augur*, having the apex constricted into a small terminal mucro.

G. *Augur* (E.). — Front view linear-cuneate, lateral view rhomboid, with subacute apex and acuminated base. EM. several figures. Europe, Asia, Australia, Africa, America. 1-960″. "More slender and with sharper point than *G. cristatum*," Rab. Professor Kützing unites *G. cristatum* to this species; and certainly they, as well as *G. Lagenula*, seem closely allied. Ehrenberg's figures vary considerably in form, but all have the apex more cuneate than we have ever seen it in *G. cristatum*.

G. *Lagenula* (K.). — Slender, linear-cuneate, finely striated; lateral view clavate, crowned with a minute point, tapering and subacute at base. KB. p. 85, pl. 30. f. 60. = *G. sphærophorum*, EM. pl. 35 A. 7. f. 14. America, Europe. Stipes short. 1-720″. This form apparently differs from *G. cristatum* only in its narrower frustule.

G. *apiculatum* (E.).—Cuneate; lateral view obovate, with acute cuneate apex and tapering base. EM. pl. 4. 2. f. 39. Fossil. America. (XII. 28 & 53.) β more slender than *G. apiculatum*: EM. pl. 2. 2. f. 43.

G. *Turris* (E.). — Much elongated, clavate, its apex suddenly acutely cuneate. EM. several figures. Africa, America, India, Japan. Ehrenberg's figures vary in form, but are mostly clavate, with or without a slight constriction above the middle. "Akin to *G. gracile*, but stouter," E.

2 † Apex in lateral view neither acute nor apiculate.

G. *abbreviatum* (Ag.). — Frustules broadly cuneate, conjoined in a flabellate manner; lateral view obovate, with indistinct striæ and rounded apex. KB. p. 84, pl. 8. f. 5–7. = *Echinella abbreviata*, Ehr. β. *longipes* (K.), stipes elongated; subbranched, = *G. rotundatum*, E. Europe, Asia, Australia, America. 1-1152″ to 1-840″. Stipes rather thick, usually very short and simple, but in var. β more elongated.

G. *sphenelloides* (Rab.). — Obovate, smooth, with broadly rounded apex; stipes simple, stout. Rab D. p. 58, pl. 8. f. 1. Italy. Front view cuneate. Probably only a form of *G. abbreviatum*.

G. *micropus* (K.).—Front view linear-cuneate, truncate at each end; lateral view obovate-lanceolate. KB. p. 84, pl. 8. f. 12. Germany, France. Very finely striated?; stipes very short and obsolete, or elongated filiform and subramose. "Resembles *G. sphenelloides*, but is smaller and more slender," R. *l. c.*

G. *tenellum* (K.). — Minute, smooth; lateral view obovate-lanceolate; stipes abbreviated, simple. KB. p. 84, pl. 8. f. 8. Europe. 1-1440″.

G. *Persicum* (Rab.). — Lateral view obovate, with rounded upper end, striated; front view broadly cuneate. Rab D. p. 59, pl. 8. f. 4. Persia. The figure represents the front view with conspicuous terminal puncta and longitudinal vittæ or suture-like lines.

G. *Hercynicum* (Rab.).—Lateral view obovate-lanceolate, with obtuse ends, the upper one cuneate; striæ distinct; front view broadly cuneate. Rab D. p. 59, pl. 8. f. 28.

G. *subramosum* (Ag.). — Lateral view clavate; front view cuneate, with acute base; stipes long, slender, nearly simple. KB. p. 85, pl. 8. f. 15. = *G. septatum*, Ag CD.; *G. oculatum*, KSA.; *G. discolor* and *G. clavatum*, E. (according to Kützing). Common. Europe, Asia, Africa, America. 1-1140″ to 1-600″. Striæ very faint. We quote *G. clavatum* (E.) under this species in deference to Kützing's authority, because the description will not determine the question; and although Ehrenberg, in his 'Microgeologie,' figures it from more than twenty stations, yet those figures differ so greatly as to afford no decisive information: several of them are lanceolate or clavate, whilst, like *G. Glans* (a species indeed described as having a general resemblance to *G. clavatum*), the greater number have an inflated centre.

G. *erosum* (Rab.). — Oblong-obovate, with emarginate apex; front view narrow-cuneate; stipes dichotomously divided. Rab D. p. 59, pl. 10. f. 12. Dresden.

5 * *Frustules in lateral view ventricose at the middle, attenuated at each end.*

G. *Glans* (E.).—Ovate-oblong, tumid; upper end rounded, with a slightly tumid neck. EM. pl. 4. 2. f. 35. Has a general resemblance to *G. clavatum*, but is shorter, stouter, and more obtuse. Ehrenberg's figures represent it with ventricose centre, broadly conical above, with rounded apex, and tapering below into a short, slenderer base.

G. *Oregonicum*, EM. pl. 37. 2. f. 12, 13. Fossil. Oregon. Ehrenberg's figure of the lateral view has an oblong inflated centre, suddenly constricted above into a cone with rounded apex, and tapering below into a slender base; the front view is large, broadly cuneate, with striated lateral margins, rounded base, and conspicuous puncta at upper end. It differs from *G. Glans* in its larger size and more elongated inflated centre.

G. *Mamilla*, EM. pl. 37. 2. f. 10. Oregon. Ehrenberg's figure of the lateral view resembles *G. Oregonicum*, but is stouter in proportion to its length, and the basal end is shorter and more truncate.

G. *giganteum* (E.). — Very large and turgid, distinctly striated, lanceolate, the subacute apex rather more acute than the base. ERBA. 1852, p. 534. Recent. California. It is more akin to *G. Mamilla* than to *G. Herculeanum*, but differs in its larger size and slenderer base. Centre inflated.

G. *Herculeanum* (E.). — Very large, minutely striated, oblong, inflated at the middle; the ends attenuate and rounded, the basal one slenderer. EM. pl. 35 A. 7. f. 12, 13. Lake Michigan, Niagara, and Oregon. Stipes long, hyaline, dichotomous; length of frustule 1-216''. Professor Kützing unites this form to *G. geminatum*; but according to Ehrenberg's figures, they are very different. The upper end is figured in this species as broadly conical, not dilated into a head as in *G. geminatum*. The front view is represented as more cuneate, and furnished with conspicuous puncta at the upper end.

G. *intricatum* (K.). — Inflated at the middle, much produced at each end, narrow, obtuse; stipes rather rigid, mucous, extremely interwoven, dichotomous. KB. p. 87, pl. 9. f. 4. Germany. Forms a firm slimy stratum on rocks. 1-420''. This species is described and figured by Kützing and Rabenhorst as slender, with inflated centre, whilst Smith describes the British forms as lanceolate, —a difference which renders their identity problematical. Front view narrow-cuneate.

G. *longiceps*, EM. pl. 7. 3 B. f. 9. Apparently common, since Ehrenberg gives thirty-eight habitats in Europe, Asia, Australia, Africa, and America. We have seen no description of this species; the figures represent it as narrow-cuneate in the front view, and the lateral view striated, inflated at the centre, with the ends elongated into beaks, the apex obtuse, and the base truncate.

G. *ventricosum* (Greg.). — Much inflated at the centre, upper end conical, lower slender, constricted above the roundish base. Greg. MJ. p. 4; pl. 1. f. 40. Scotland. ·0013'' to ·0018''. This form much resembles *G. Glans*; the base, however, is dilated and rounded—characters wanting in the figures of that species.

G. *Cygnus* (E.).—Narrow, with a lanceolate inflated centre, and linear, elongated, beak-like extremities. EM. pl. 5. 3. f. 33. America, Asia. Obtuse at apex, and truncate at base. Kützing thinks this may be identical with his *Sphenella rostellata*.

G. *Vibrio* (E.). — Elongated, inflated at the middle, and gradually tapering into long beak-like extremities; the upper one subacute. EM. pl. 39. 3. f. 71. Cayenne. SD. i. p. 81, pl. 38. f. 242. (XII. 35.) "Akin to *G. gracile*, but longer, more slender, and approaching to *Pinnularia amphioxys*" (E.).

G. *rostratum* (Sm.). — Lateral view ovate-elliptical, produced at the upper extremity into a linear obtuse rostrum, slightly constricted below; striæ 30 in ·001''. SBD. ii. p. 99. Barleylake, Co. Cork. ·0009'' to ·0012''. Stipes distinct.

G.? *Hebridense* (Greg.).—Lateral view elongated, narrow-lanceolate, with inflated centre, acute equal apices, and very fine striæ. Greg. MJ. ii. p. 99. pl. 4. f. 19. Mull deposit. Professor Gregory remarks that it seems to stand between *G. tenellum* and *G. Vibrio*, but that, only its lateral view having been seen, its genus is uncertain.

C* *Frustules lanceolate in the lateral view.*

G. *dichotomum* (K.). — Lateral view narrow-lanceolate, with slightly obtuse apices, striated; front view narrow-linear, cuneate. SD. i. p. 79, pl. 28. f. 240. = *G. gracile*, EM. numerous figures. Common. 1-1150'' to 1-860''. Stipes usually elongated and dichotomous, but sometimes abbreviated and sub-simple. The frustules somewhat resemble those of *G. olivaceum*, but are narrower; their puncta also are far less distinct. This species appears generally diffused, since Ehrenberg gives upwards of 100 habitats, scattered over the world.

G. *lanceolatum* (E.). — Lateral view striated, lanceolate, with acute ends; front view linear-cuneate, very gradually tapering at each end. KB. p. 87, pl. 30. f. 59. America. Ehrenberg's figures represent the lateral view broader than in *G. dichotomum*.

G. *affine* (K.). — Rather turgid, elongate, striated; margins in front view slightly curved; lateral view sublanceolate, with an obtuse apex. KB. p. 86, pl. 30. f. 54. Trinidad. 1-360″. Stipes abbreviated, subramose. "It differs from *G. dichotomum* in its firmer habit and broader sides; lateral apices more obtuse" (K.). According to Rabenhorst, it is slenderer than *G. lanceolatum*, but scarcely specifically distinct.

G. *Fibula* (Bréb.). — Slender, elongated, very narrow-cuneate; lateral view acicular, very slender; stipes short, nodule obsolete. KSA. p. 65. France, England. Akin to *G. dichotomum*, but differs in its slenderer frustules.

G. *exiguum* (K.). — Minute, smooth, lateral view lanceolate; stipes slender, subramose. KB. p. 84, pl. 30. f. 58. Marine. France, Jutland. 1-1440″.

G. *cuspidatum* (Rab.).—Cuneate, often curved; lateral view smooth, lanceolate, with acute ends. Rab D. p. 59, pl. 8. f. 22. Saxony. With or without a stipes.

G. *æquale* (Greg.).—Lateral view lanceolate, with minutely capitate apices, an exactly central nodule, and conspicuous striæ. Greg. MJ. iv. p. 12, pl. 1. f. 41. Scotland. ·001″. Striæ 22 to 24 in ·001″. It agrees nearly with some forms of *G. tenellum*, from which, however, it differs in having much wider and coarser striæ, and in the central position of the nodule, Greg. *l. c.* A slight constriction exists beneath each end. Professor Smith refers it to *G. tenellum*.

G. *insigne* (Greg.).—Lateral view lanceolate, slightly rhomboid, with obtuse ends; striæ 18 to 20 in ·001″. Greg. MJ. iv. p. 12, pl. 1. f. 39. Scotland. ·0016″ to ·0025″. "Distinguished by its size and the coarseness of its striation. Side view doubly conical, the angles at the broadest part being strongly marked." Professor Smith thinks it may be a form of *G. Sarcophagus*.

G. *Sarcophagus* (Greg.).—Lateral view clavate, lanceolate, constricted near the extremities, which are minutely capitate. Greg. MJ. iv. p. 13, pl. 1. f. 42. Scotland. ·0014″. Striæ 20 to 22 in ·001″. Widest part about one-third from apex. Professor Gregory compares the outline to that of a coffin.

G. *minutissimum* (K.).—Linear-cuneate, smooth, with a slender subbranched stipes; lateral view narrow-lanceolate. KB. p. 84, pl. 8. f. 11. Marine. Britain. (XII. 17.) Kützing regards this as the *G. minutissimum* of Greville; but that opinion is doubtless erroneous; for this is a marine, and Greville's was an aquatic gathering in which *G. olivaceum* and *G. curvatum* were mixed together.

G. *auritum* (Braun.).—Broadly cuneate in front view, the upper end truncate, with an awn at each angle; lateral view lanceolate, with a terminal awn. Rab D. p. 59, pl. 8. f. 3. Baden. Habit of *G. intricatum*, but furnished with awnlike spines.

G. *Naviculoides* (S.).—Stipes distinct and regularly dichotomous; front view sublinear, truncate; lateral view acutely lanceolate, with the extremities equal and nodule central. SBD. ii. p. 98. In the Victoria Regia tank, Edinburgh. According to Professor Smith, this species, in a lateral view, is not to be distinguished from a Navicula, as the nodule is almost exactly central.

Species insufficiently described, or known to us only by name.

G. *digitatum* (K.). — Frustules very minute and smooth, linear-cuneate, flabellate; stipes simple, dilated above. KB. p. 84, pl. 21. f. 2. 2. Marine. Cuxhaven. 1-680″. Kützing gives no description or figure of the lateral view.

G. *telographicum* K.).—Frustules minute and very smooth, slender, cuneate, somewhat more acute at base, umbellately aggregated on a simple abbreviated stipes dilated at its apex. KB. p. 84, pl. 8. f. 9. Maritime. Heligoland. 1-1200″.

G. *crassum* (Rab.). — Front view broadly cuneate, truncate above, rounded at base; the lateral margins convex, faintly striated. Rab D. p. 59, pl. 10. f. 13. Persia. Although only the front view is described and figured, yet the species seems well distinguished by the convex (not straight) lateral margins, giving it an obovate form with the broader end truncate. The puncta are conspicuous in the figure, as are also two longitudinal lines or vittæ.

G. *pulvinatum* (Braun). — Front view broad, linear-cuneate; base smaller than the very thick, serpentine, irregularly divided stipes. Rab D. p. 58, pl. 8. f. 16. Zurich. "Forms little, very thick, smooth knoblike cushions of equal height."

G.? *contractum* (K.). — Very minute, attenuated at the base, slightly constricted at the middle, with a dilated rounded apex; stipes simple, abbreviated or obsolete. KB. p. 86, pl. 14. f. 21. 3. Germany. 1-1440″. Kützing's figure, which is very minute and pyriform, shows no median line, nodule, or striæ.

G. insulare (E.), *G. tenuicolle* (E.), Australia; *G. longicolle* (E.), Australia, Asia, America; *G. Jordani* (E.), River Jordan; *G. obtusum* (E.), Arabia, America; *G. turritum* (E.), Arabia; *G. mucronatum* (E.), *G. rhomboideum* (E.), Asia; *G. Mosambicense* (E.), Africa; *G. Margaritaceum* (E.), *G. Savannæ* (E.), British Guinea; *G. lanceolatum* (E.), America; *G. Palea* (E.), fossil, Jura Mountains, France.

Genus SPHENOSIRA (E.). — Frustules united into a straight compressed filament; lateral surfaces with unequal extremities and a distinct central nodule. Aquatic. The frustules in front view are scarcely cuneate; and the genus could be better placed in the Naviculeæ, as indeed Kützing himself suggests; it seems to differ from them only in the unequal ends of the lateral surfaces.

SPHENOSIRA *Catena* (E.).—Frustules smooth; lateral view with a mucro at apex and a gradually attenuated, somewhat obtuse base. EA. p. 98, pl. 3. 1. f. 27; KB. p. 88, pl. 29. f. 47. Mexico. (xi. 30.)

FAMILY XVIII.—NAVICULEÆ.

Frustules free, concatenate, or included in a more or less definite frond; front view generally linear or quadrangular; valves with similar ends, a median longitudinal line, and central nodule. "The Naviculeæ frequently resemble individuals in other families, but are to be distinguished by the central nodule of the lateral surfaces, as well as by the regularity and symmetry both of these and the front view" (Menegh.). In the minuter forms the nodules are frequently very indistinct; when present, however, they usually appear, in the front view, like a punctum at the middle of each lateral margin. In doubtful cases this appearance will often aid in ascertaining their presence.

* *Frustules nude.*

Genus NAVICULA (Bory, Rab.).—Frustules simple, free, prismatic in front view, rectangular laterally, with a longitudinal median pellucid line with central and terminal nodules. Navicula was divided by Ehrenberg into two genera—Navicula with smooth, and Pinnularia with striated valves; but this division was not received by Kützing or Brébisson, and is certainly unsound, as it assigns the species to each genus according to the power of the author's microscope, whilst striæ, we believe, are almost always, if not universally, present on the valves. The late Professor Smith reconstituted Ehrenberg's genera, and made their characters depend on the presence or absence of costæ. These characters were far better than those of Ehrenberg; and were the costæ always plainly developed as in *Pinnularia nobilis* and its allies, no difficulty could occur in determining the genera; but in many of the more minute species it is often very difficult to distinguish between striæ and costæ. We have not admitted Pinnularia here, partly for the reason just given, but principally because we cannot decide to which genus a large number of Ehrenberg's species should be referred.

A. *Valves more or less constricted at the middle* (Diploneis, E.).

NAVICULA *Americana* (E.).—Turgid, linear-oblong, with slightly constricted centre and broadly rounded ends; striæ wanting or indistinct. EM. pl. 2. 2. f. 16. New York and Rhode Island.

N. *Faba* (E., K.).—Turgid, oblong, slightly constricted at the middle and rounded at the ends, marked by longitudinal lines; striæ wanting or indistinct. = *Diploneis Faba*, EB. 1845, p. 365. River Tagus. The median line interrupted by the central nodule; three lines on each side continuous.

N. *hyalina* (E., K.). — Slightly constricted at the middle, with oblong lobes, rounded ends, a longitudinal median fascia of lines, and a narrow pinnulated border. = *Diploneis? hyalina*, EB. p. 362. Marine. India. May be more akin to *Cymatopleura Solea.*

N. *binodis* (E.). — Smooth, minute, narrow panduriform, with acuminated rostrate apices; median nodule very distinct. EB. 1840, p. 18; KB. p. 100, pl. 3. f. 35. = *Fragilaria? binodis*, EA. p. 127. Fossil, Santa Fiore; recent in pools, &c.

N. *duplicata* (E.). — Smooth, small, rather broad panduriform, with attenuate subacute apices. EM. pl. 21. f. 35. Cuba. In Ehrenberg's figure the ends are somewhat cuneate, and the median line simple.

N. *incurva* (Greg.).—Small, smooth, sublinear, with a shallow sinus on each side, and ends suddenly contracted into obtuse subcapitate beaks. MJ. iv. p. 8, pl. 1. f. 26. Scotland.

N. *constricta*, EM. pl. 38. 17. f. 3. Volcanic ashes, Iceland. Ehrenberg represents it as smooth, minute, panduriform; ends rounded, each terminated by a minute nipple-like point; median line simple.

N. *emarginata*, EM. pl. 39. f. 83. Ehrenberg's figure is minute, smooth, panduriform, with each end suddenly contracted into an obtuse, broad, mammiform beak.

N. *paradoxa* (E.).—Large, smooth; oblong, slightly constricted at the middle, with four longitudinal median lines and somewhat obtuse cuneate ends. EA. pl. 1. 3. f. 4. 6. Peru.

N. *imperialis* (E., K.).—Dilated, with constricted middle and subacute apices, a simple series of conspicuous granules accompanying the middle furrow, which is smooth on both sides; lateral series alike, two perfect ones inclosing an imperfect median sinus, all interrupted at the middle. = *Diploneis imperialis*, EB. 1845, p. 362. Marine. India. Granules large, pearl-like.

N. *Entomon* (E.). — Large; slightly sinuato-constricted at the middle, with oblong lobes and subacute cuneate ends; striæ 19 or 20 in 1-1200″. EB. 1840. = *Pinnularia Entomon*, EA. pl. 1. 1. f. 3, 4; *Diploneis Entomon*, EM. pl. 19. f. 30. Marine. Fossil, Greece; recent, Europe, Asia, Africa. Distinguished by its shallow stricture and smooth striæ.

N. *Conops* (E., K.).—Small, panduriform, very finely striated, with cordate lobes and acute apiculate apices. = *Pinnularia? Conops*, EA. pl. 3. 7. f. 20. America.

N. *incurvata* (Greg.).— Panduriform, with rounded ends; striæ 30 in ·001″, minutely moniliform; median line straight, with dark shaded lines on each side. TM. iv. p. 44, pl. 5. f. 13. Marine. Scotland.

N. *splendida* (Greg.). — Large, panduriform, much constricted, with elliptic-oblong lobes and obtusely triangular ends; striæ distinctly moniliform. TM. iv. p. 44, pl. 5. f. 14. Marine. Scotland. Median line straight, and having on each side a narrow blank space.

N. *Proserpinæ* (E.). — Very large, deeply constricted; lobes almost rhomboid, with subacute apices; sides striated, lines decussating at a right angle, a broad, pellucid, smooth median fascia divided by two lines into three parts; umbilicus circular. = *Diploneis Proserpinæ*, EB. 1858, p. 13. Marine. Ægean Sea.

N. *Musca* (Greg.). — Small, panduriform, with turgid lobes and acute cuneate apices; striæ rather distant, coarse, moniliform, short, forming a marginal band. GDC. p. 7, pl. 1. f. 6. Marine. Scotland. Striæ 18 in ·001″; median line and nodule distinct.

N. *Bombus* (E., K.). — Panduriform, with subcordate lobes and subacute apices; striæ dense, coarsely moniliform. KSA. p. 83. = *Pinnularia Bombus*, ERBA. 1844; GD. pl. 1. f. 12; *Diploneis Bombus*, EM. pl. 19. f. 31. Europe. 1-384″; striæ 21 in 1-1200″. Granules of the largest striæ in fours. Median line broad, with a square central nodule. Characterized by its short turgid lobes and close, large, pearly granules.

N. *didyma* (E., K.). — Rather broad, slightly constricted at the middle, with short suborbicular lobes and broadly rounded ends; striæ distinct, granulate. KB. p. 100, pl. 4. f. 7; SD. i. pl. 17. f. 154. = *Pinnularia didyma*, EA. pl. 2. 4. f. 3. Marine. Europe, Asia, Africa, America. (VII. 61; XV. 12.)

N. *dissimilis* (Rab.). — Large, panduriform, with broadly rounded ends; striæ stout, curved, converging, not reaching the median line; front view gibbous at the centre and tapering towards the ends, which are truncate. = *Pinnularia dissimilis*, Rab. p. 45, pl. 6. f. 32. Persia.

N. *Pandura* (Bréb.). — Large, elongated panduriform, with elliptic lobes and obtuse apices; costæ smooth. BD. pl. 15. f. 4. = *Pinnularia Pandura*, GDC. p. 17, pl. 1. f. 22; *N. nitida*, TM. iv. p. 44, pl. 5. f. 12. Europe. M. de Brébisson regards this form as distinct from *N. Crabro*, E.; and it undoubtedly is from the Trinidad Diatom figured by Dr. Greville for that species. We consider, however, that *N. Pandura*, Bréb. not only agrees in its smooth costæ with Ehrenberg's description and figure of *N. Crabro*, but also better in shape than does Greville's *N. Crabro*, in which the constricted portion is less elongated—a fact pointed out by Greville himself.

N. *Crabro* (E., K.).— Panduriform, deeply constricted; lobes ovate or oblong, with subacute apices; striæ distinct, obscurely moniliform, nitescent, 10 in ·001″. KA. p. 83?; SBD. ii. p. 94; MJ. v. pl. 3. f. 11. = *Pinnularia Crabro*, ERBA. 1844, p. 85?; *Diploneis Crabro*, EM. pl. 19. f. 29? Fossil, Ægina; recent, America, Europe. Although we defer to the opinions of Brébisson, Smith, and Greville, yet we think it highly probable that the preceding species is the one intended by Ehrenberg for *D. Crabro*.

N. *gemmata* (Grev.).— Broad linear-oblong, obtuse, with straight or slightly concave sides; striæ moniliform, interrupted, 10 in ·001″, with a single row of puncta near the median line. Edin. New Phil. Journ. n.s. x. pl. 4. f. 7. Californian guano. Distinguished by its distant striæ, which form a linear marginal band. Its affinity is with *N. Crabro* and its allies.

N. *nodulosa* (Bréb., K.).—Minute, oblong, constricted at the middle; ends contracted into obtuse mammiform beaks; transverse striæ not reaching the median line. KB. p. 101, pl. 28. f. 71. = *Pinnularia Termes*, EM. pl. 39. f. 100. Recent, Cuba, Mexico, Africa; fossil, Franzensbad.

N. *gemina* (E.). — Small, striated, divided by a median constriction in both views into two lenticular lobes; in lateral view terminated by a median apiculus. EB. 1840, p. 19. Mouth of the River Elbe. 1-840″ to 1-648″.

N. *Apis* (E., K.).— Oblong, so much constricted as to be nearly divided into two semiorbicular lobes; striæ slender, granulate; stricture smooth. KB. p. 100, pl. 28. f. 76. = *Pinnularia Apis*, EA. iii. pl. 7. f. 18. Mexico, Africa. Distinguished by its smooth stricture and its finely granulate striæ (12 in 1-1200″).

N. *interrupta* (K.). — Sinuato-constricted at the middle, with broadly elliptic lobes and rounded ends; striæ interrupted opposite the nodule. KB. p. 100, pl. 29. f. 93. = *Navicula*, BAJ. 1842, pl. 2. f. 18. Marine. America, Jutland.

B. *Valves divided into three or more portions by two or four constrictions, but not constricted at the centre* (Nodosæ).

N. *Silicula* (E.). — Smooth, linear elongated, divided by two constrictions into three nearly equal nodes; apices obtuse. EM. numerous figures. = N. *ventricosa*, E. Apparently common, since Ehrenberg gives upwards of fifty habitats in Europe, Asia, Australia, Africa, and America. This species might be placed with almost equal propriety in the following section.

N. *polyonca* (Bréb.).—Elongated, bacillar, sublinear, divided by two constrictions into three nodes, the middle one largest; ends roundish-capitate; striæ wanting or indistinct. KA. p. 85. = *Pinnularia undulata*, MJ. ii. p. 97, pl. 4. f. 10. France, Britain.

N. *Hitchcockii* (E.).— Smooth, linear-oblong, each margin with three undulations; apices suddenly cuneate, subacute. EM. pl. 5. 3. f. 11. America. (VII. 62.)

N. *limosa* (K.).—Smooth or obscurely striated, linear, with two constrictions and three inflations, the middle one largest; ends cuneate, subacute. KB. pl. 3. f. 50. Germany.

N. *nodosa* (E.).—Linear, smooth or obscurely striated, with three nearly equal inflations; ends contracted into short obtuse beaks. KB. p. 100, pl. 28. f. 82. Common, especially in small pools by the road-side. (IX. 143.) β, striæ more evident. = *Pinnularia Legumen*, EM. many figures. 1-430″. Approaches *N. Hitchcockii*.

N. *trinodis* (S.).—Valves with two constrictions, three nearly equal inflations, rounded ends, and obscure striæ.

N. *mesolepta* (E.).—Smooth, elongated, linear, with three inflations, the middle one smallest; ends strongly contracted into short obtuse beaks. EM. pl. 17. 2. f. 17. America, France. 1-420″.

N. *nivalis* (E.).—Minute; linear, somewhat narrow in the middle, with tricrenate sides and obtuse apices. EB. 1853, p. 528; EM. pl. 35 B. A 2. f. 5. Monte Rosa. Differs from *N. undosa* in its stouter apices: *N. nodosa* is larger and more slender. Ehrenberg's figure shows the valves very minute, with four constrictions and five nodules, including the capitate ends, which nearly resemble the others in size and form.

N. *Formica* (E.). — Smooth, linear, with four constrictions and five oblong nodes. EM. pl. 4. 3. f. 8. Recent, United States; fossil, Finland.

N. *Monile* (E., K.).—Striated, linear, constricted, with five, nearly equal subglobose nodes, including the capitate ends. = *Pinnularia Monile*, EM. pl. 17. 1. f. 12; *Pinnularia isocephala*, EM. pl. 5. 3. f. 21. Berlin, America. It has the ends more capitate and the striæ stronger than *N. nodosa*.

N. *Kochii* (E., K.).—Large, elongated, lanceolate, with subacute apices, each side with three undulations, the middle one most distinct; striæ oblique; the median smooth band very broad, extending to the apices. KA. p. 84. = *Pinnularia Kochii*, EB. 1845, p. 364. Fossil. Kurdistan.

N. *Pyrenaica* (S.).—Elongated, slender linear, with three inflations, the median one greatest; striæ indistinct. ANH. 1857, xix. p. 8, pl. 2. f. 5. Pyrenees.

N. *undosa* (E.). — Small, smooth, broadly oblong-lanceolate, with three undulations on each side, and conical apices. EM. pl. 39. 3. f. 90. America, Africa, Asia, France. Ehrenberg describes it as akin to *N. Hitchcockii*. Rabenhorst remarks that it resembles *N. Persica* in form, but is scarcely one-third its size and has no secondary undulating ribs.

N. *Persica* (Rab.). — Large, oblong-lanceolate, with obtuse mammiform apices; each side with five undulations, and four corresponding longitudinal undulated lines on each side the median one. Rab D. p. 41, pl. 6. f. 55. South Persia. Broadest at the centre, and tapering in a pyramidal manner to each apex.

N. *integra* (S.). — Small, lanceolate, with slightly undulated margins and contracted apiculate apices; striæ indistinct, 36 in ·001″, reaching the median line and most evident opposite the central nodule. = *Pinnularia integra*, SD. ii. p. 96; *N. rostrata*, MJ. iv. pl. 1. f. 14. Britain.

N. *undulata*. = *Pinnularia mesotyla*, EM. pl. 16. 3. f. 27. Sweden, India. Ehrenberg's figure somewhat resembles that of *N. undosa* in form, but is longer and has parallel transverse striæ.

C. *Valves elongated linear or lanceolate, with gibbous or inflated centre: central costæ, when present, usually converging, and often leaving a dilated smooth space round the median nodule.*

N. *mesotyla* (E.).—Small, smooth or indistinctly striated, narrowly linear, with a central spherical inflation and slightly contracted obtuse apices. EA. p. 131, pl. 4. 2. f. 7.; EM. pl. 1. 3. f. 14. Asia, Africa, America. 1-420″.

N. *inconspicua* (Greg.).—Small, smooth, hyaline, linear, with rounded ends and slightly gibbous centre; median line strong, complex, interrupted by the definite central nodule. GD. p. 6, pl. 1. f. 3. Scotland.

N. *lævissima* (K.).—Minute, vitreous, clear, linear, with broadly rounded ends and slightly gibbous centre; striæ wanting or indistinct; central nodule stauros-like. KB. p. 96, pl. 21. f. 14. = *Stauroneis rectangularis*, MJ. ii. pl. 4. f. 17 (according to Smith). Fossil, Santa Fiore; recent, Britain. 1-570″.

N. *tumidula* (Rab.). — Small, linear, with rounded, slightly enlarged ends, and inflated centre; central nodule stout. Rab D. p. 41, pl. 5. f. 9. Stockholm. Closely allied to *N. Silicula*.

N. *scopulorum* (Bréb.). — Elongated, slender linear, with central and terminal inflations; striæ very faint, reaching the median line, 56 in ·001″. KA. p. 81. = *N. mesotyla*, KB. p. 99, pl. 5. f. 3; *Pinnularia Johnsonii*, SD. i. pl. 19. f. 179. In marine or brackish waters. France, Britain. Front view turgid at the middle. M. de Brébisson assures us that Smith's species is identical with his *N. scopulorum*; but Kützing's figure and description would not lead us to infer the identity.

N. *gibberula* (K.).—Linear, with gibbous centre and very slightly enlarged, obtuse, subtruncate apices; striæ very fine. KB. p. 101, pl. 3. f. 50*. Europe.

N. *leptogongyla* (E.). — Elongated, slender linear, striated, tumid in the middle; apices slightly dilated, oblong, obtuse. KB. p. 99, pl. 4. f. 9; EA. p. 130. = *Pinnularia leptogongyla*, EM. many figures. Europe, America. Lough Mourne deposit. Rabenhorst says that this species has double the breadth of *N. scopulorum*.

N. *mesogongyla* (E., K.). — Styliform or bacillar, striated, with gibbous middle, and broadly rounded but not dilated ends. KA. p. 81. = *Pinnularia mesogongyla*, EM. pl. 10. 2. f. 2. Asia, Africa, America. Akin to *N. nobilis*, but without dilated ends.

N. *nobilis* (E., K.).—Very large, elongated, broadly linear, gradually dilated at centre, and broadly rounded ends; costæ oblique, stout, close, not reaching the median line. KA. p. 80. = *Pinnularia nobilis*, EB. 1840, p. 20; SD. i. pl. 17. f. 161. Europe, America, Asia, Australia. 1-84"; nodules large; costæ 16 to 18 in 1-1200".

N. *gigas* (E., K.).—Very large, elongated; broadly linear, with gibbous centre, and broadly rounded, slightly attenuated ends; costæ broad, close, not reaching the median line. KA. p. 80.=*Pinnularia gigas*, EM. pl. 2. 3. f. I. America. Akin to *N. nobilis*; nine pinnules in 1-1200".

N. *major* (K.).—Large, turgid, linear-oblong, with slightly tumid centre and broadly rounded ends; costæ converging at the centre, stout, 12 in 1-1200". KB. p. 97, pl. 4. f. 19, 20.=*Pinnularia major*, SD. pl. 18. f. 161; *Pinnularia viridis*, E., in part. Common. (VII. 65; XII. 15, 31; XVI. 1-6.) This species scarcely differs from *N. nobilis* and *N. gigas*, except by its somewhat smaller size and closer pinnules.

N. *acrosphæria* (K.). — Elongated, slender linear, with dilated centre and ends, rounded apices, and seventeen short thick costæ in 1-1200", which do not reach the median line. KB. p. 97, pl. 5. f. 2. = *Pinnularia acrosphæria*, Rab D. p. 45, pl. 6. f. 36; SD. pl. 19. f. 183. Europe. Front view narrow-linear.

N. *pachyptera* (E., K.).—Large, bacillar, but short and stout, with gibbous centre and broadly rounded ends, which are not constricted; pinnules stout, not reaching the median line, 6 in 1-1200". KB. p. 98, pl. 28. f. 58. = *Pinnularia pachyptera*, E. Labrador, Australia.

N. *hebes* (Ralfs).—Small, oblong, with gibbous centre and broadly obtuse ends; striæ distinct, 33 in ·001", nearly reaching the median line.=*N. obtusa*, SD. i. p. 50, pl. 16. f. 140. Britain.

N. *cocconeiformis* (Greg.). — Small, subelliptic, with tumid centre and slightly contracted, broad, obtuse ends; striæ indistinct, median line straight, nodule definite. MJ. iv. p. 6, pl. 1. f. 32; Grev. ANH. 2nd series, xv. pl. 9. f. 6. Scotland. It much resembles *Achnanthidium flexellum*, but its median line is quite straight, Greg.

N. *Macula* (G.).—Small, oblong, with tumid middle, and very broad, subtruncate ends; striæ very fine, parallel, nearly reaching the median line, except opposite the large, transverse, quadrate indefinite median space. TM. iv. p. 43, pl. 5. f. 9. Marine. Britain. Striæ about 70 in ·001". In shape not unlike large specimens of *Achnanthidium flexellum*, but the median line is straight. The central nodule is obsolete and is replaced by the large, stain-like blank space, Greg.

N. *gibba* (E., K.).—Bacillar, striated, lanceolate, with dilated capitate ends. KB. p. 98, pl. 28. f. 70. = *Pinnularia gibba*, EA. pl. 1. 2. f. 3; SD. pl. 19. f. 180. Common. Europe, Asia, Africa, America. Striæ close, not reaching the median line, 30 in ·001".

N. *Tabellaria* (E., K.).—Bacillar, elongated, striated, rather turgid, ventricose at the middle, with dilated, broadly rounded apices. KB. p. 98, pl. 28. f. 79. =*Pinnularia Tabellaria*, EA. pl. 2. 1. f. 26; SD. i. pl. 19. f. 181. Europe, Asia, Africa, America. (XII. 21.) The central dilatation tapers less than in *N. gibba*, and the striæ are more distant. It is more slender than *N. nobilis*.

N. *porrecta* (E., K.). — Large, elongate-lanceolate, broadly tumid at the middle, and gradually tapering into the broadly obtuse apices; striæ oblique. KA. p. 81. = *Pinnularia porrecta*, EA. p. 133. North America. Akin to *N. decurrens*.

N. *decurrens* (E., K.).— Striated, narrow, elongate-lanceolate, tumid at the centre, somewhat narrowing towards the ends, which are broadly rounded. KA. p. 81.=*Pinnularia decurrens*, EM. many figures. β slenderer,=*Pinnularia Trabecula*, E. γ, striæ obsolete,=*Navicula Trabecula*, E. Ehrenberg gives upwards of 80 habitats. Akin to *N. gibba*.

N. *Esox* (E., K.).—Large, elongated, striated, narrow-lanceolate, with slightly gibbous centre and attenuated but obtuse ends; striæ parallel, nearly reaching the median line. KB. p. 94, pl. 28. f. 53.= *Pinnularia Esox*, EA. p. 133, pl. 1. 2. f. 4. Chili. (XII. 43.)

D. *Valves with a smooth, transverse middle fascia.*

N. *cardinalis* (E.). — Large, broadly linear, with rounded ends; costæ stout, radiant, 9 in ·001", interrupted by a smooth, transverse median band.=*Pinnularia cardinalis*, SD. i. pl. 19. f. 166; *Stauroptera cardinalis*, EM. several figures; *Stauroneis cardinalis*, KB. p. 106, pl. 29. f. 10. Europe, Asia, Australia, Africa, America. (XII. 72.) A well-marked species, easily recognized by its large size, rounded not attenuated ends, and coarse striæ, which are shorter near the transverse median fascia. Perhaps this and other species having a transverse smooth median fascia might advantageously be retained in Stauroneis, notwithstanding that the fascia is not formed by a thickened prolongation of the central nodule.

N. *divergens* (S.). — Large, oblong-lanceolate, somewhat contracted towards the rounded ends; costæ radiate at centre, interrupted by a smooth transverse median fascia, 11 in ·001″. = *Pinnularia divergens*, SD. i. p. 57, pl. 18. f. 177. Britain. The costæ near the central nodule are shorter and radiant; the others are divergent.

N. *Brébissonii* (K.). — Linear-oblong, with obtuse ends; costæ fine, indistinct, close, 30 in ·001″, not reaching the median line, interrupted by a transverse median fascia. KB. p. 93, pl. 3. f. 49. = *Pinnularia stauroneiformis*, SD. i. p. 57, pl. 19. f. 178. Europe. Front view linear, with rounded angles.

N. *globiceps* (Greg.).—Minute, narrow linear-oblong, constricted beneath the globular ends; costæ fine, distinct, not reaching the median line, interrupted by a transverse median blank band, 36 to 40 in ·001″. = *Pinnularia globiceps*, MJ. iv. p. 10, pl. 1. f. 34. Scotland. Distinguished by its capitate apices and transverse cross-like median band.

N. *parva* (E.). — Linear, constricted beneath the capitate ends; costæ 24 in ·001″, interrupted at the middle by a transverse, blank, cross-like band. = *Stauroptera parva*, EA. p. 135, pl. 3. 1. f. 19; *Stauroneis parva*, KB. p. 106, pl. 29. f. 23; *Pinnularia interrupta*, SBD. i. p. 59, pl. 19. f. 184. Europe, Asia, America. Transverse band dilated outwards.

N. *Bohemica*, EM. pl. 10. 1. f. 4. Bohemia. Ehrenberg's figure is rhomboid, with obtuse apices, three median lines, between which and the margins are longitudinal series of dots, all interrupted by a transverse median blank space, but no distinct nodule; front view narrow-linear, with rounded ends.

N. *Claviculus* (Greg.).—Narrow-linear, with two constrictions; central inflation small, smooth; terminal ones oblong-clavate, striated; striæ parallel, nearly reaching the median line, about 32 in ·001″. GD. p. 6, pl. 1. f. 5. Scotland. Nodule definite; front view linear, with rounded angles, broader than the lateral view, the margins striated except at the middle.

E. *Frustules in the lateral view having the striæ on each side of the median line divided into two series (a marginal and a median) by a longitudinal line, blank space, or fascia.*

† Valves elliptic.

N. *Lyra* (E.). — Elliptic or elliptic-oblong, marked by two narrow longitudinal blank spaces, which are connected by the central nodule, in the form of a lyre; striæ 22 to 24 in ·001″, often indistinct, the middle ones longest. = *Navicula* and *Pinnularia Lyra*, E., GD. p. 13, pl. 1. f. 13; *N. Gregoriana*, Grev. MJ. v. p. 10, pl. 3. f. 7. Marine. Europe, Asia, Africa, America. *N. Lyra*, var. *recta*, Grev., large, oblong-lanceolate obtuse; blank lines narrow, contracted at the nodule, otherwise parallel with the median line; striæ 24 in ·001″: Edin. New Phil. Jour., n.s., x. pl. 4. f. 3: Californian guano: distinguished by its large size and straight blank lines. Either *N. Lyra* is very variable, or more than one species has been included under the name. The valve is either rounded at the ends or (more usually) has a short, produced, conical point. The blank spaces are linear, inclined inwards at the nodule, and the tips, which are attenuated, usually bent outwards, but are sometimes straight or even incurved.

N. *approximata* (Grev.). — Oblong, with produced, conic apices; striæ interrupted, 17 in ·001″; outer band broad, not dilated opposite the nodule; blank lines linear, nearly straight. Grev. Edin. New Phil. Jour., n.s., x. pl. 4. f. 10. Californian guano. Allied to *N. Lyra*, but distinguished by the total absence of any contraction of the blank spaces opposite the nodule. From *N. Hennedyi* it differs in its linear, subparallel blank spaces, and larger blank space round the nodule.

N. *irrorata* (Grev.).— Broad, parallelogramic or oblong, suddenly contracted at the ends into mammiform apices; striæ 15 in ·001″, forming a broad-linear marginal band, and a narrow one of very unequal breadth next the median line; blank spaces not reaching the ends. Grev. *l. c.* f. 1. Californian guano.

N. *forcipata* (Grev.).—Oval or oblong, with rounded apices, and marked by two narrow longitudinal blank spaces, which diverge from the nodule in a curved manner and converge at the apices; striæ 35 in ·001″, the middle ones longest. MJ. vii. pl. 6. f. 10, 11. Marine. Britain. Distinguished from *N. Lyra* by its smaller size, closer striæ, and connivent points of the blank spaces.

N. *nummularia* (Grev.). — Suborbicular; striæ moniliform, about 24 in ·001″, interrupted by two narrow-linear blank lines which contract opposite the nodule, then curve outwards, converge, and meet at the terminal nodules. Grev. Edin. New Phil. Jour., n.s., x. pl. 4. f. 6. Californian guano. Valve small; striæ concentric with the extremities. The blank spaces have a considerable resemblance to those of *N. forcipata*, Grev.

N. *spectabilis* (Greg.).—Broadly elliptic, gradually tapering to the obtuse apices; blank spaces broadly linear, converging at nodule and ends; striæ 22 in ·001″, coarsely moniliform, the outer series forming a broad marginal band much dilated opposite the nodule. GD. p. 9, pl. 1. f. 10. Marine. Scotland. Large (inner) bands of striæ linear. Distinguished from *N. Lyra* by broader blank spaces and the brown colour of the striated portions; its nodule also is indefinite.

N. *suborbicularis* (Greg.). — Small, broadly oval or suborbicular; striæ conspicuous, about 18 in ·001″, divided by a longitudinal line into two series, outer one broadest opposite the indefinite central nodule. = *N. Smithii suborbicularis.* GD. p. 15, pl. 1. f. 17. Marine. Scotland.

N. *Couperi* (Bailey). — Large, oblong, with slightly constricted sides and contracted mammiform apices; striæ punctate, divided into series by two narrow longitudinal blank bands united by the transverse nodule. = *Pinnularia Couperii*, BMO. p. 39, pl. 2. f. 3. United States. The outline is like that of *N. paradoxa*; and the markings somewhat resemble those of *N. Lyra*, *β*. Blank spaces connivent at their apices.

N. *Hennedyi* (S.). — Elliptical, with rounded or mammiform ends; striæ moniliform, divided into series by two narrow, lunate longitudinal blank spaces, the marginal series of nearly equal breadth throughout. SBD. ii. p. 93; Greg. MJ. iv. pl. 5. f. 3. = *Stauroneis angulata*, Johnston, MJ. viii. p. 13. Marine. Britain. (VII. 69.) Striæ 24 in ·001″, not perceptibly longer opposite the central nodule, which is indefinite.

N. *clavata* (Greg.).—Broadly elliptical, with apices produced into mammiform points; striæ moniliform, divided into series by two arcuate longitudinal blank spaces bent outwards at their ends; marginal series of nearly equal breadth throughout. TM. iv. pl. 5. f. 17. Marine. Scotland. Striæ 20 in ·001″, not perceptibly longer opposite the central nodule, which is indefinite.

N. *nebulosa* (Greg.).—Elliptic-oblong; blank spaces large, semilunate; striæ fine, 34 to 36 in ·001″, forming a narrow marginal band of equal breadth. GD. p. 8, pl. 1. f. 8. Marine. Scotland. Inner bands of striæ, very narrow linear, close to median line. Aspect of valve hazy and indistinct; striated portions bluish under a low power; nodule indefinite.

N. *prætexta* (E.). — Large, elliptic with broadly rounded ends; striæ distinctly moniliform, 8 to 10 in ·001″, forming a marginal border of nearly uniform breadth, which is separated from the narrow median band by a large sparsely granular space on each side. EB. 1840, p. 20; GD. p. 9, pl. 1. f. 11. = *Pinnularia prætexta*, EM. pl. 19. f. 28. Marine, Scotland; fossil, Greece. 1-288″. This species is distinguished by its large size, coarse striation, much rounded ends, and a broad semilunate space between the marginal and inner bands of striæ, furnished with scattered granules.

N. *Californica* (Grev.). — Broadly elliptic, with flattened sides; striæ moniliform, divided into narrow marginal and median bands by a large, semilunate, smooth intermediate space on each side the median line. Grev. Edin. New Phil. Jour., n.s., x. pl. 4. f. 5. Californian and S. African guanos. Marginal striæ 20 in ·001″. Differs from *N. prætexta* in having the sides of the valve flattened, and the broad intermediate space between the marginal and median striæ smooth.

N. *polysticta* (Grev.).—Elliptical; striæ moniliform, forming a narrow marginal band, separated from the median line by an irregularly punctate, lunate intermediate space; striæ 25 in ·001″. Grev. *l. c.* f. 2. Californian guano. Valve minute. Differs from *N. prætexta* in its smaller size and far less rounded ends.

N. *Smithii* (Bréb.). — Elliptic, with rounded apices; striæ distinct, 21 in ·001″, interrupted on each side of the median line by a longitudinal line; the inner series narrow, fainter. = *N. elliptica*, SD. i. p. 48, pl. 17. f. 152. Marine. Europe. The outer series of striæ is broad, but not dilated opposite the central nodule.

N. *fusca* (Greg.). — Large, elliptic-oblong, with broadly rounded ends; striæ coarsely moniliform, about 10 in ·001″, divided on each side by a longitudinal line into two series, the inner one fainter. = *N. Smithii*, *β fusca*, GD. p. 14, pl. 1. f. 15. Marine. Scotland. Differs from *N. Smithii* in its much larger size and more distant striæ. Nodule indefinite; median smooth space narrow lanceolate.

N. *nitescens* (Greg.).—Small, elliptic-lanceolate, with obtuse apices; striæ obscurely moniliform, about 16 in ·001″, converging at centre, divided on each side by a longitudinal line into two series, reaching the median line.=*N. Smithii, γ nitescens*, GD. p. 15, pl. 1. f. 16. Marine. Scotland. Colourless under a low power; median line linear, nodule definite. Distinguished from *N. Smithii* by its smaller size, the characters of nodule and median line, and its bright-white aspect.

N. *quadrifasciata* (E.). — Elliptic-oblong, with attenuated, obtuse ends; striæ 20 in 1-1200", divided on each side of the median line into two linear series. EB. 1840. = *Pinnularia quadrifasciata*, EM. pl. 19. f. 25–27; *N. lineata*, Donkin, MT. vi. p. 32, pl. 3. f. 17? Marine. Fossil, Greece; recent, Britain. 1-430". Series of striæ separated by a narrow blank line.

N. *elliptica* (K.).—Elliptic or linear-elliptic, with rounded ends; striæ distinct, connivent, 27 in ·001", divided into two series on each side the median space by a longitudinal line.=*N. Parmula*, KA. p. 80; *N. ovalis*, SD. i. p. 48, pl. 17. f. 153. Europe.

N. *pygmæa* (K.).—Minute, elliptic or oblong-elliptic, with rounded ends, hyaline, with very faint, close striæ, and a panduriform blank median space. KA. p. 77.=*N. minutula*, SD. i. p. 48, pl. 31. f. 274. In brackish or fresh water. France, England. Although the striæ, which are very indistinct, are not interrupted, yet the peculiar form of its median space shows that its proper position is in this group.

N. *æstiva* (Donkin). — Large, narrow-elliptic, with rounded ends; striæ fine, distinct, costate or obscurely moniliform, reaching nearly to the median line, crossed on either side near their inner ends by a longitudinal line. TM. vi. p. 32, pl. 3. f. 18. Marine. Northumberland. This beautiful species differs from *N. Smithii* in its more gracefully elliptical figure, in its costate and much finer striæ, and in the darker-brown colour when mounted in balsam. The dry valve is pale-brown. Donkin.

N. *Allmaniana* (Greg.).—Small, oval, with subacute apices; costæ about 20 in ·001", somewhat radiant, nearly reaching the median line, divided by a line near to and concentric with the margin.= *Pinnularia Allmaniana*, GD. p. 16, pl. 1. f. 21. Marine. Scotland. The marginal series of costæ narrow, conspicuous, border-like; the inner one fainter.

2 † Valves linear, with dilated centre and ends.

N. *Rabenhorstii* (Ralfs). — Elongated, slender, gradually dilated at centre and broadly rounded ends; striæ fine, short, divided on each side the median line by a narrow, blank, longitudinal line.=*Pinnularia interrupta*, Rab D. p. 44, pl. 6. f. 3. Italy. Divided by two constrictions into three oblong portions; the interrupting line undulated like the margins. This species resembles a slender *N. nobilis* with interrupted striæ.

F. *Valves with capitate or rostrate apices.*

† Valves inflated or ventricose.

N. *Crux* (E.). — Cruciform, with diverging costæ, which do not reach the median line. = *Pinnularia Crux*, EM. pl. 12. f. 37. Asia, Cassel. This species has the lateral view like a Biblarium, but with median line and nodule.

N. *Trochus* (E.). — With strongly inflated middle, and obtuse, rostrate ends, longitudinally striated. E Inf. p. 179, pl. 21. f. 8. Fossil. Sweden. 1-860".

N. *inflata* (K.).—Minute; with much inflated centre, and short, obtuse, beak-like ends; striæ wanting or indistinct. KB. p. 99, pl. 3. f. 36=*N. Follis*, EM. several figures. Fossil, Sweden, Santa Fiore; recent, Europe.

N. *amphisbæna* (Bory). — Inflated, elliptic, with capitate or conic apices; striæ close, delicate. E Inf. p. 178, pl. 13. f. 7; SD. i. p. 51, pl. 17. f. 147. Common. Europe, Asia, Africa, America. (VII. 72; IX. 141.) 1-1700" to 1-240". Median nodule orbicular. The *Pinnularia amphisbæna*, EM., is probably a state of this species exhibiting more conspicuous striæ.

N. *Placenta* (E.).—Minute, ventricose, roundish-elliptic, with a nipple-like projection at each apex. EM. pl. 33. 12. f. 23. Oregon.

N. *sphærophora* (K.).—Elliptic-lanceolate, strongly constricted into capitate or conic apices; striæ wanting or indistinct. KB. p. 95, pl. 4. f. 17; SD. i. p. 52, pl. 17. f. 148. Europe, Asia. Very similar to *N. amphisbæna*, but it is less inflated, and it appears destitute of striæ. According to Rabenhorst, it differs also by having faint longitudinal lines. 1-320".

N. *brevis* (Greg.). — Small, elliptic, contracted into short, broad, mammiform ends; striæ fine, about 35 in ·001", nearly reaching the median line, shorter opposite the indefinite central nodule. GD. p. 6, pl. 1. f. 4. Scotland. Professor Walker Arnott is probably correct in uniting this to *N. amphisbæna*.

N. *tumens* (S.).—Inflated, elliptic, with the ends suddenly contracted into short, obtuse beaks; striæ indistinct, 36 in ·001″. SD. i. p. 52, pl. 17. f. 150. Brackish water. England.

N. *pusilla* (S.).—Small, inflated, elliptic, suddenly contracted into short, conic beaks; striæ distinct, punctate, radiant, 26 in ·001″. SD. i. p. 52, pl. 17. f. 52. = *N. gastroides*, Greg. MJ. iii. p. 40, pl. 4. f. 17. Brackish water? Britain. Prof. Gregory distinguished his *N. gastroides* from this species by its stouter habit, larger size, and having a brown colour even in balsam; but we unite them as Professor Smith has done, being unwilling to add another doubtful species to this group, which we believe is already too numerous.

N. *Anglica* (Ralfs).—Minute, elliptic, suddenly constricted beneath the roundish capitate ends; striæ very distinct, punctate, radiate, reaching the median line, 24 in ·001″. = *N. tumida*, SD. i. p. 53, pl. 17. f. 146.

N. *Carassius* (E.). — Small, inflated, broadly lanceolate, with the ends suddenly contracted into short, conical beaks; striæ wanting or indistinct. EA. p. 130, pl. 2. 2. f. 11. France, America. Is smaller than *N. amphisbæna*.

N. *capitata* (E.). — Minute, with inflated centre, and short, obtuse, beak-like ends; striæ diverging, 10 in 1-1200″. E Inf. p. 179, pl. 13. f. 20. = *Pinnularia capitata*, EM. pl. 35 A. 1. f. 4. Europe, Asia, Australia, America. 1-1150″ to 1-576″.

N. *Semen* (E.). — Small, elliptic-oblong, slightly contracted into the broad, obtuse ends; striæ obsolete or apparent. EA. pl. 4. 2. f. 8; in EM. many figures; SD. i. p. 50, pl. 16. f. 141. β, striæ distinct, = *Pinnularia Semen*, EM. Europe, Asia, Africa, America.

N. *æqualis* (E., K.).—Inflated, elliptic-lanceolate, suddenly contracted at the ends into nipple-like points; striæ fine. KSA. p. 77. = *Pinnularia æqualis*, EA. 131; EM. many figures. Europe. Lough Mourne deposit, Iceland.

N. *diomphala* (E.). — Striated, short, broadly lanceolate, suddenly contracted into obtuse beaks; median nodule transverse, divided by a longitudinal line into two parts. EA. p. 132, pl. 3. 7. f. 25. America.

N. *Gastrum* (E., K.).—Small, striated, inflated, elliptic, contracted at the ends into short conical beaks; striæ radiant. KB. p. 94, pl. 28. f. 56. = *Pinnularia Gastrum*, EM. several figures; *Pinnularia Placentula*, EM. several figures. Asia, Africa, America.

N. *birostrata* (Greg.). — Ventricose, elliptic-oblong, with shortly rostrate apices; striæ fine, close, radiant, reaching nearly to the median line. MJ. iii. p. 40, pl. 4. f. 5. Scotland.

N. *tæniata* (E.). — Small, inflated, elliptic, suddenly contracted into minute, rounded, conical beaks; pinnules strong, forming a narrow marginal border. = *Pinnularia tæniata*, EM. pl. 39. f. 95. The pinnules separated from the median line by a broad blank space. Perhaps a Mastogloia. (xv. 15.)

N. *biceps* (E.). — Small, turgid, lanceolate, slightly constricted into obtuse, conical apices; striæ wanting or indistinct. EA. p. 130; EM. many figures. Europe, Africa, America. Rather more slender than *N. amphisbæna*.

N. *crassula* (Nägeli). — Smooth, elliptic, with capitate apices; front view broadly linear, truncate. 1-720″. KSA. p. 890. Switzerland.

N. *sculpta*, EM. pl. 10. 1. f. 5. Bohemia, Asia, America. Ventricose, suddenly tapering into short, broad, obtuse beaks, the median line interrupted by the indefinite nodule, which extends on one side in a semicrucial smooth band; the rest of the surface granulated. Front view linear, with rounded angles and gibbous sides.

N. *signata* (E.). — Minute, inflated, prolonged into narrow beaks; striæ radiant, reaching the median line, the six central ones stronger. = *Pinnularia signata*, EM. pl. 34. 6 A. f. 7. Florida.

N. *Rostellum* (S.).—Small, ventricose, oval, with the apices produced into point-like beaks; striæ indistinct, 80 in ·001″. SBD. ii. p. 93 = *N. apiculata*, Greg. MJ. iv. pl. 1. f. 13. Britain.

2 † Valves lanceolate.

N. *Crassinervia* (B.). — Minute, lanceolate, with shortly rostrate apices; striæ wanting or indistinct. SD. i. p. 47, pl. 31. f. 271. France, Britain.

N. *rhynchocephala* (K.). — Slender, lanceolate, with longly rostrate apices; striæ wanting or obscure. KB. p. 152, pl. 30. f. 35; SBD. p. 47, pl. 16. f. 132. Europe. Is longer and more slender than *N. cryptocephala*, with more produced apices. (vii. 68.)

N. *leptorhynchus* (E.).—Small, smooth, linear-lanceolate, with straight, subacute, longly rostrate apices. EA. p. 130. Mexico. Akin to *N. dirhynchus*, but with longer beaks.

N. *leptocephala* (Rab.).—Small, lanceolate, with elongated, slender, obtuse, somewhat clavate beaks; striæ wanting or indistinct. Rab D. p. 39, pl. 6. f. 69. Europe.

N. *exilis* (K.).—Very minute, smooth, lanceolate, with produced, obtuse apices. KB. p. 95, pl. 4. f. 6. Germany.

N. *rostrata* (E.). — Finely punctated, broadly lanceolate, almost rhomboid, rapidly tapering into acute beaks; central nodule large. EB. 1840, p. 18; KB. p. 94, pl. 3. f. 45. Fossil. Santa Fiore. 1-216″. Front view linear, with truncate apices.

N. *Charontis* (E.).—Elongated, smooth, oblong-lanceolate, with the ends contracted into conic beaks. EB. 1845, p. 239; EM. pl. 35. BB. f. 12. Four times as long as broad.

N. *Otrantina* (Rab.). — Oblong-lanceolate, with rounded, slightly contracted ends. Rab D. p. 44, pl. 6. f. 42.

N. *dirhynchus* (E.).—Small, narrow-lanceolate, with conic, rostrate apices; striæ wanting or indistinct. EA. p. 130, pl. 3. 1. f. 11. Falaise, Mexico.

N. *Garganica* (Rab.). — Minute, lanceolate, suddenly contracted into short, thick, obtuse apices; striæ distinct, oblique, reaching the median line, six near the central nodule stouter than the rest. =*Pinnularia Garganica*, Rab D. p. 44, pl. 6. f. 41. Italy.

N. *amphiceros* (K.).—Minute, broadly lanceolate, with produced, rostrate apices, and fine striæ. KB. p. 95, pl. 3. f. 39. Germany, Asia.

N. *stelligera* (E., K.).—Rhomboid-lanceolate, with the apices suddenly attenuated into obtuse beaks; the very fine punctated pinnules distinctly radiating from the orbicular, smooth umbilical space. KA. p. 70. =*Pinnularia stelligera*, EB. 1845, p. 364. Marine. India.

N. *Petersii* (E., K.)—Dilated, large at each end, suddenly attenuated into a very short beak; median line double, with a narrow, longitudinal umbilical space; pinnules very fine. KA. p. 70. =*Pinnularia Petersii*, EB. 1845, p. 364. Mouth of the river Tagus.

N. *guttulifera* (Rab.).—Minute, slender, acicular, with a glass-like globe at each apex. RD. p. 40, pl. 6. f. 74. South Persia.

N. *pachycephala* (Rab.). — Minute, slender-lanceolate, constricted beneath the capitate apices; striæ converging; central nodule stout, terminal ones obsolete. = *Pinnularia pachycephala*, RD. p. 43, pl. 6. f. 40. Italy.

N. *cincta*. = *Pinnularia cincta*, EM. pl. 10. 2. f. 6. Bohemia. This species is figured as minute, lanceolate, with obtuse apices; striæ oblique, those opposite the central nodule radiant and stouter than the others.

N. *Gregorii* (Ralfs). — Small, narrow linear-lanceolate, contracted at the ends into minute beaks; striæ distant, parallel, scarcely reaching the median line. = *Pinnularia apiculata*, Greg. MJ. iii. p. 41, pl. 4. f. 21. Scotland.

N. *angustata* (S.).—Minute, narrow-lanceolate, constricted beneath the capitate apices; striæ indistinct, 45 in ·001″. SD. i. p. 52, pl. 17. f. 156. = *N. dicephala β*, KA. p. 76? Britain, Falaise. Front view narrow-linear.

N. *cryptocephala* (K.).—Very minute, lanceolate, with globose, capitate apices; striæ wanting or indistinct. KB. p. 95, pl. 3. f. 20. Europe.

N. *Veneta* (K.). — Very minute, lanceolate, rather broad, with produced, slightly obtuse apices; striæ wanting or indistinct. KB. p. 95, pl. 30. f. 76. Brackish water, Venice. Resembles *N. cryptocephala*, but is shorter and broader.

N. *Fusidium* (E.). — Narrow-lanceolate, distinctly but slightly constricted beneath the capitate apices. EM. pl. 5. 3. f. 4. America, Asia.

N. *leptostylus* (E.). — Lateral view turgid-lanceolate, suddenly tapering into short beaks with capitate apices. = *N. Platalea*, EM. pl. 15 A. f. 42.

N. *amphirrhina* (E.) = *Pinnularia amphirrhina*, EM. pl. 15 A. f. 20. Lough Mourne deposit, Japan, America. Ehrenberg figures this species as inflated-lanceolate, rapidly tapering into subacute beaks; striæ parallel.

N. *amphirhynchus* (E.). — Small; turgid-lanceolate, suddenly constricted at the ends into short, subcapitate beaks; striæ indistinct or wanting. EA. pl. 3. 1. f. 10; KA. p. 76. Europe, Asia, Australia, Africa, America. (XII. 6.)

N. *amphistylus* (E., K.).—Elongated bacillar, with turgid middle, attenuated, filiform, obtuse apices, and delicate pinnules. KSA. p. 75. =*Pinnularia amphistylus*, EB. 1845, p. 79. Fossil. Oregon. 1-372″.

N. *ordinata* (Bréb.).—Minute, smooth, connected in a parallel manner into short, fragile filaments; valves slender-lanceolate, contracted at the ends into short, often capitate beaks. Bréb. = *N. aponina β*, KA. p. 69. Falaise.

N. *eurycephala* (Rab.). — Large, robust, oblong, slightly contracted at the ends into very short and broad, truncate beaks. Rab D. p. 40, pl. 6. f. 70. Germany. Median line and nodule strongly developed. Resembles *Stauroneis platystoma*, but with a rounded, not transverse median nodule.

3 † Valves linear.

N. *dicephala* (E.). — Elongated linear, constricted at the ends into capitate or broadly conical beaks; striæ either obscure or distinct, 19 in 1-1200". = *Navicula* and *Pinnularia dicephala*, EM. many figures; *Pinnularia biceps*, Greg. MJ. iv. pl. 1. f. 28? Common. Europe, Asia, Africa, America. 1-860" to 1-480".

N. *producta* (S.). — Linear, abruptly contracted at the ends into short, obtuse beaks; striæ faint, 42 to 48 in ·001". SD. i. p. 51, pl. 17. f. 144. = *N. amphirynchus*, SD. i. p. 51, pl. 16. f. 142. Britain. (VII. 66.)

N. *birostris* (E.).—Elongated narrow-linear, suddenly contracted at the ends into conical apices; striæ distinct, close, parallel. = *Pinnularia birostris*, EM. pl. 15 A. f. 24. Fossil. Lough Mourne deposit; Sweden. This form seems scarcely to differ from *N. dicephala*, except in having slenderer frustules.

N. *gracillima* (Greg.).—Slender, narrow-linear, constricted beneath the capitate apices; costæ fine, 27 in ·001", not reaching the median line. = *Pinnularia gracillima*, MJ. iv. p. 9, pl. 1. f. 31; SD. ii. p. 95; *Pinnularia tenuis*, MJ. ii. pl. 4. f. 9? Britain.

N. *linearis* (Greg.).—Minute, narrow-linear, constricted beneath the subcapitate ends; costæ very fine, about 40 in ·001", parallel, reaching the median line. = *Pinnularia linearis*, MJ. iv. p. 8, pl. 1. f. 29. Scotland.

N. *subcapitata* (Greg.).—Minute, narrow-linear, constricted beneath the capitate ends; striæ subdistant, conspicuous, short. = *Pinnularia subcapitata*, MJ. iv. p. 9, pl. 1. f. 30. Scotland.

N. *Elginensis* (Greg.).—Minute, linear, constricted beneath the subquadrate capitate ends; striæ fine, about 30 in ·001", slightly oblique, reaching the median line. = *Pinnularia Elginensis*, MJ. iv. p. 9, pl. 1. f. 33. Scotland.

N. *limpida* (Perty). — Rather large, striated, broadly linear-oblong, suddenly contracted at the ends into short, broad, obtuse beaks. Perty, Mic. Org. of Alps, p. 204, pl. 17. f. 9. Alps. Front view linear, with truncate ends; striæ 10 to 11 in 1-1200".

N. *Pisciculus* (E., K.). — Elongated, slender, striated, narrow-linear, slightly contracted at the ends into conic beaks; striæ very delicate. KA. p. 75. = *Pinnularia Pisciculus*, EA. pl. 2. 1. f. 30. Cayenne, India, Falaise.

N. *limbata* (E.).—Small, linear, each end suddenly contracted into a short, broad, truncate beak, and a wide border appearing within. EA. p. 130, pl. 1. 2. f. 16. Chili.

N. *longiceps* (Greg.). — Minute, narrow-linear, with the ends contracted into short, obtuse points; nodule indefinite; striæ wanting or inconspicuous. MJ. iv. p. 8, pl. 1. f. 27. Scotland.

N. *affinis* (E.).—Small, linear-oblong, with the ends suddenly contracted into short, broad, obtuse beaks; striæ wanting or indistinct. EA. p. 129, pl. 2. 2. f. 7; SD. i. p. 50, pl. 16. f. 143. Very common. Ehrenberg gives upwards of seventy habitats. (XII. 32.) 1-570" to 1-420". Resembles *N. dicephala*.

N. *dubia* (E.). — Small, linear-lanceolate, with the ends suddenly contracted into conic beaks; striæ wanting or indistinct. EA. p. 130, pl. 2. 2. f. 8. Asia, Australia, Africa, America. Akin to *N. affinis*.

N. *ambigua* (E.). — Small, oblong, somewhat inflated, with the ends suddenly contracted into short, conic beaks; striæ wanting or indistinct. EA. pl. 2. 2. f. 9; EM. pl. 15 B. f. 15. America, Australia, Lough Mourne deposit. Resembles *N. affinis* and *N. dicephala*.

N. *rostellata* (K.). — Minute, striated, linear-oblong, with elongated, rostrate, acute apices. KB. p. 95, pl. 3. f. 65. Wangerooge.

N. *columnaris* (E.).—Large, elongated, broadly linear, suddenly contracted into short, very broad, rounded ends, and marked by numerous longitudinal lines. EM. pl. 14. f. 23. Berlin.

N. *ampliata*, EM. pl. 17. 2. f. 7, & pl. 15 A. f. 32. Finland, Siberia, Lough Mourne deposit. Ehrenberg's figures represent this species as large, smooth, broadly linear, suddenly contracted at the ends into broad, rounded, mammiform beaks.

N. *Vespa* (R.).—Small, linear-oblong, constricted beneath the capitate apices; nodules minute; striæ parallel, close, nearly reaching the median line. = *Pinnularia Vespa*, EM. pl. 33. 5. f. 9. Asia, Africa, America.

N. *incurva* (Greg.). — Small, linear, with slightly sinuated sides; ends contracted into short truncate beaks; striæ wanting or inconspicuous. MJ. iv. p. 8, pl. 1. f. 26. Scotland.

N. *apiculata* (Bréb.).—Striated, linear, suddenly attenuated at each end into a short apiculus; front view broad, quadrate, with striated lateral margins: striæ strong, 14 in ·001″, nearly reaching the median line. Bréb DC. p. 16, pl. 1. f. 20. = *Pinnularia rostellata*, GDC. p. 16, pl. 1. f. 20. Marine. Europe. Striæ somewhat radiant. The frustules are much compressed, and very similar in the front view to those of *N. retusa*.

4† Valves subquadrate or elliptical, with conical terminal points.

N. *lacustris* (Greg.). — Small, oblong or subquadrate, with acute or shortly rostrate apices; striæ fine, distinct, slightly oblique, nearly reaching the median line, 28 or 30 in ·001″. MJ. iv. p. 6, pl. 1. f. 23. Scotland. The only species with which this could be confounded is *N. firma*; but the latter is longer and larger, of a brown colour, with finer, less conspicuous, and parallel striæ.

N. *humerosa* (Bréb.).—Striated, subquadrate; ends truncate, with a minute, conic central point; striæ fine, moniliform, 24 in ·001″, radiant, reaching nearly to the median line, shorter opposite the roundish umbilical space. SD. ii. p. 94. = *N. quadrata*, Greg. TM. iv. p. 41, pl. 5. f. 5. Marine. Europe. According to Dr. Donkin, the dry valve, under a low power, is hyaline and colourless.

N. *granulata* (Bréb.).—Striated, rather large, elliptic or subquadrate; ends with a conic central point; striæ conspicuously moniliform, 16 in ·001″, radiant, reaching nearly to the median line. Donkin, TM. vi. pl. 3. f. 19. Marine. Europe. Distinguished from *N. humerosa* by its more distant and coarsely granulated striæ. "Dry valve of a dull bluish colour, inclining to purple" (Donkin).

N. *compacta* (Grev.). — Small, subquadrate, with slightly concave sides, rounded shoulders, and the median line prolonged into conic points; striæ faint, 42 in ·001″, reaching nearly to the median line. Greg. MJ. v. p. 11, pl. 3. f. 8. Marine. Not uncommon. The striæ are nearly parallel. A species well marked by its quadrate shape.

N. *latissima* (Greg.).—Broadly elliptic, with slightly produced mammiform apices; striæ distinct, finely moniliform, radiant, nearly reaching the median line, shorter, and leaving an orbicular hyaline space round the central nodule. TM. iv. p. 40, pl. 5. f. 4. Marine. Britain. (VII. 70.) Distinguished from *N. granulata* by its straw or light-brown colour in balsam, and less conspicuous granules.

N. *Barclayana* (Greg.). — Elliptic-oblong, with minute, conic apices; striæ about 38 in ·001″, finely moniliform, short, forming a narrow marginal band, and enclosing a large, lanceolate smooth median space. GDC. p. 8, pl. 1. f. 9. Marine. Britain. The marginal striated band is of nearly uniform breadth, except near the base, where it becomes narrower.

N. *marina* (Ralfs).—Oval, with slightly produced conic apices, and 33 distinct, moniliform, radiant striæ in ·001″, which reach the median line. = *N. punctulata*, SD. p. 52, pl. 16. f. 151. Marine. England.

N. *producta* (Ralfs).—Oblong-elliptic, much constricted at each end, as if obtusely mucronate; surface elegantly marked by decussating punctated lines; puncta in quincunx. = *N. decussata*, EB. 1843, p. 256. Habit of *N. Amphisbæna*.

6. *Valves lanceolate or rhomboid.*

N. *rhomboides* (E.). — Rhomboid-lanceolate, with subacute apices and 85, very faint, parallel striæ in ·001″. EA. pl. 3. 1. f. 15; SBD. i. p. 46, pl. 16. f. 129. Mexico, Europe, Australia.

N. *rhombica* (Greg.). — Rhomboid-lanceolate, with very fine but distinct striæ, 45 in ·001″, reaching the median line. MJ. iii. p. 40, pl. 3. f. 16; TM. iv. p. 38, pl. 5. f. 1. Marine. Scotland. (VII. 71.) According to Professor Gregory, *N. rhombica* is distinguished from *N. rhomboides* by the different appearance of its median line and central nodule, as well as by its distinct striæ.

N. *rhombea* (E.).—Broadly rhomboid-lanceolate, with acute apices, and delicate longitudinal lines on each side; transverse striæ wanting or indistinct. EA. p. 131, pl. 3. 7. f. 27. Mexico. 1-480″ to 1-360″.

N. *Demeraræ* (E.). — Smooth, rhomboid, tumid, strongly tapering into acute, subrostrate apices. EB. 1845, p. 79. Demerara. 1-576″. "Distinguished from *N. rhombea* only by its subrostrate ends" (Rabenhorst).

N. *decussata* (E., K.). — Rhomboid-lanceolate, with subacute apices, an obsolete umbilical space, and very fine, decussating, punctated striæ. KA. p. 70. = *Pinnularia decussata*, EB. 1845, p. 364. Marine. India.

N. *Indica* (E.). — Rhomboid-lanceolate, with somewhat obtuse apices, a small umbilicus, and thick-set, fine, longitudinal, punctated lines (8 on each side). EB. 1845, p. 363. Marine. India. Somewhat resembles *N. decussata*.

N.? *asperula* (E., K.).—Turgid, short, rhomboid-lanceolate, six-angled, rough with punctated striæ; umbilicus suborbicular; the longitudinal median space much dilated near the umbilicus. KA. p. 71. = *Pinnularia? asperula*, EB. 1845, p. 364. Marine. India.

N. *Libellus* (Greg.). — Rhomboid-lanceolate, with obtuse ends; striæ fine, uniform, about 60 in ·001″, reaching the median line; front view broadly linear, with the central portion longitudinally lined. GDC. p. 57, pl. 6. f. 101. Scotland. In form it much resembles *N. rhombica*, but is more obtuse and broader, with uniform striæ. Professor Walker-Arnott regards this species as escaped frustules of *Schizonema Grevillii*,—an opinion, indeed, shared by Professor Gregory himself.

N. *subtilis* (Greg.).—Elongated, translucent, very slender, rhomboid-lanceolate, with a minute, definite nodule; costæ about 30 in ·001″, parallel, reaching the median line. = *Pinnularia subtilis*, GDC. p. 16, pl. 1. f. 19. Marine. Scotland.

N. *lanceolata* (Ag., K.). — Minute, narrow-lanceolate, with 44 indistinct, parallel striæ in ·001″. KB. p. 94, pl. 28. f. 38; SD. i. p. 46, pl. 31. f. 272. Europe, America.

N. *serians* (K.). — Small, lanceolate, with fine longitudinal lines, and subacute apices; front view broadly linear. KB. p. 92, pl. 28. f. 43; SD. i. p. 47, pl. 16. f. 130. = *N. lineolata*, EM. several figures. Europe, Asia, Australia, Africa, America. 1-288″. Frustules frequently cohering.

N. *Subula* (K.).—Elongated, slender, narrow-lanceolate, with tapering, subacute apices, and fine longitudinal lines. KB. p. 91, pl. 30. f. 19. Marine. Europe.

N. *tenella* (Bréb.). — Minute, smooth, very narrow-lanceolate, with acute apices; front view linear, slightly constricted at the middle. KA. p. 74. Europe.

N. *amphioxys* (E.).—Elongated, narrow-lanceolate, with acute apices; striæ indistinct or wanting. EA. pl. 1. 2. f. 8; EM. many figures. Europe, Asia, Australia, Africa, America, Lough Mourne deposit. More slender than *N. gracilis*. Front view narrow-linear.

N. *Cari* (E.).—Minute, smooth, lanceolate, slender, acute at both sides, with a circular median nodule. EI. p. 179; EM. pl. 12. f. 20. Fossil. Cassel. 1-1150″.

N. *oxyphyllum* (K.).—Pellucid, glassy, smooth, slender-lanceolate, gradually tapering to the acute apices; median nodule obsolete. KB. p. 92, pl. 30. f. 17. Marine. Near Flinsburg.

N. *velox* (K.). — Minute, smooth, broadly or oblong lanceolate, with acute apices. KB. p. 91, pl. 3. f. 66. = *N. oblonga*, EA. pl. 3. 1. f. 14. Wangerooge, Mexico.

N. *aponina* (K.). — Minute, smooth, slender-lanceolate, with acute, subrostrate ends. KB. p. 91, pl. 4. f. 1. Europe. Front view narrow-linear.

N. *Cesatii* (Rab.). — Minute, smooth, slender-lanceolate; front view linear, with rounded ends. Rab D. p. 39, pl. 6. f. 89. Piedmont. Very like *N. aponina*, but more slender in the lateral, and broader in the front view.

N. *digito-radiata* (Greg.).—Small, oblong-lanceolate, with obtuse ends; striæ fine, distinct, about 25 in ·001″, reaching the median line, those near the central nodule more distinct and highly radiant. = *Pinnularia digito-radiata*, MJ. iv. p. 9, pl. 1. f. 32. Scotland.

N. *solaris* (Greg.). — Elongated, narrow-lanceolate, with obtuse ends; striæ fine, very distinct, 36 in ·001″, oblique, radiant, and shorter opposite the indefinite central nodule. TM. iv. p. 43, pl. 5. f. 10. Marine. Scotland. Colour brown; striæ so highly radiant round the central blank spot as to present the appearance of a sun with rays. It is longer than *N. radiosa*, with finer and more inclined striæ.

N. *Mediterranea* (K.).—Minute, narrow-lanceolate, with obtuse apices and 20 striæ in 1-1200″; front view strictly linear, truncate. KB. p. 93, pl. 3. f. 17. Marine. Europe. 1-1200″.

N. *punctulata*, EM. pl. 15 A. f. 34, B. f. 13, 14. Lough Mourne deposit, Sweden, Africa. Ehrenberg figures this species as rhomboid-lanceolate, with longitudinal, parallel, dotted lines.

N. *appendiculata* (Ag., K.).—Minute, lanceolate, with slightly turgid middle and subrostrate obtuse ends. KB. p. 93, pl. 3. f. 28. = *Frustulia* and *Cymbella appendiculata*, Ag. Europe. Front view linear, with truncate ends. In the lateral view the apices are somewhat produced, but scarcely rostrate.

N. *obtusa* (E.). — Small, oblong-lanceolate, with obtuse, rounded apices. EA. p. 131. North America, Asia, Africa. Kützing thinks it probably identical with *N. appendiculata*.

N. *inflexa* (Greg.).—Small, lanceolate, with subacute apices; costæ conspicuous, 26 in ·001", highly radiant, nearly reaching the median line, except opposite the central nodule, where they are short, leaving a large, roundish blank space. = *Pinnularia inflexa*, TM. iv. p. 48, pl. 5. f. 20. Scotland. Beneath each apex is a strong, dark cross-bar, probably caused by a depression, Greg.

N. *fortis* (Greg.). — Small, oblong-lanceolate or somewhat rhomboid, with obtuse apices; costæ conspicuous, 16 in ·001", not reaching the median line, gradually shorter and more radiant near the central nodule. = *Pinnularia fortis*, TM. iv. p. 47, pl. 5. f. 19. Scotland. Turgid; costæ prominent, so as to appear more distant than they actually are.

N. *mutica* (K.).—Very minute, smooth, turgid-lanceolate, with distinct median and terminal nodules. KB. p. 93, pl. 3. f. 32. Wangeroogc. 1-1560".

N. *Jurgensii* (K.). — Minute, smooth, turgid or oblong-lanceolate, with obtuse apices and obsolete median nodule; front view broadly linear, with truncate ends. KB. p. 93, pl. 3. f. 8. Island of Wangerooge, Germany. 1-720".

N. *viridula* (K.). — Small, lanceolate, with obtuse, slightly produced apices; striæ wanting or indistinct. KB. p. 91, pl. 4. f. 10. 15. Europe.

N. *carinata* (E.). — Large, lanceolate; front view linear, with a broad dorsal longitudinal keel. EB. 1840, p. 18. Fossil. Shores of the Rhine, in volcanic schists: 1-216".

N. *diaphana* (E.). — Large, smooth, diaphanous, elongated, lanceolate, with obtuse apices; the umbilicus intercepting the double median line. EB. 1845, p. 78. Guiana. 1-192". Habit of *Stauroneis phœnicenteron*.

N. *Schomburgkorum* (E.). — Large, elongated, lanceolate, with obtuse apices, and the habit of *N. diaphana*, but with three longitudinal median lines. EB. 1845, p. 79. Guiana. 1-180".

N. *latiuscula* (K.). — Rather large, oblong or elliptic-lanceolate, with rather obtuse apices; striæ shorter opposite the central nodule, 10 to 12 in 1-1200". KB. p. 93, pl. 5. f. 40. = *N. patula*, SD. i. p. 49, pl. 16. f. 139. Europe, Ireland. Twice as long as broad; front view broadly linear, with truncate ends.

N. *Schomburgkii* (E., K.). — Large, lanceolate, equal, three times as long as broad, with subacute apices, and 25 striæ in 1-1152". KA. p. 71. = *Pinnularia Schomburgkii*, EB. 1845, p. 80. Guiana. Is smaller and more obtuse than *N. æqualis*.

N. *palpebralis* (Bréb.). — Broadly lanceolate, with subacute apices, and 27 radiant striæ in ·001", which do not reach the median line. SD. i. p. 50, pl. 31. f. 273. Marine. France, Britain. Striæ short, leaving a lanceolate median blank space.

N. *angulosa* (Greg.).—Broadly lanceolate or oblong, with subacute apices; striæ conspicuous, short, forming a narrow marginal band, shorter near the middle, and leaving a smooth, rhomboid median space. TM. iv. p. 42, pl. 5. f. 8. Marine. Britain. *N. angulosa* is larger than *N. palpebralis*, and the angular median space is a good and permanent mark of distinction; nodule definite.

N. *radiosa* (K.). — Small, slender-lanceolate, with subacute apices, and from 15 to 18 distinct, radiant striæ in 1-1200". KB. p. 91, pl. 4 f. 23. = *Pinnularia radiosa*, SD. i. p. 56, pl. 18. f. 173. Germany, Britain. With stronger striæ than *N. gracilis*.

N. *vulpina* (K.).—Rather turgid, lanceolate, with acute apices; front view broadly linear, with truncate ends and punctate margins; striæ obscure. KB. p. 92, pl. 3. f. 43. Germany. Intermediate between *N. gracilis* and *N. cuspidata*.

N. *cuspidata* (K.). — Broadly lanceolate, with acute apices, a very minute, orbicular central nodule, and close, very fine transverse striæ. KB. p. 94, pl. 3. f. 24, 37; SD. i. p. 47, pl. 16. f. 131. = *Navicula fulva*, EM. many figures. Common. Europe, Asia, Africa, America. (XII. 5.) Front view narrow-linear. 1-1150" to 1-180". The lateral view is broader and more rhomboid than in *N. gracilis*.

N. *Cantonensis* (E.).—Broadly oblong-lanceolate, with acute, slightly produced apices; striæ wanting or indistinct. EB. 1847, p. 484. Canton. 1-480". It differs from *N. cuspidata* in its shorter and acute apices.

N. *amphisphenia* (E.). — Lanceolate, navicular, gradually attenuated into the apices, with an oblong median nodule; striæ wanting or obscure. EA. p. 129; EM. pl. 9. 1. f. 16. America, Asia, Africa, Europe. Distinguished from *N. cuspidata* by its oblong nodule.

N. *phyllepta* (K.). — Minute, slender,

smooth, narrow-lanceolate, with acute apices; front view strictly linear, with truncate ends. KB. p. 94, pl. 30. f. 56. Marine. Europe.

N. *Meleagris* (K.).—Somewhat turgid, lanceolate-acuminate, with an elegantly punctate margin. KB. p. 92, pl. 30. f. 37. Marine. Europe. Front view broadly linear.

N. *gracilis* (E.). — Small, elongated, slender-lanceolate, with subacute ends; striæ very fine, radiant, 22 in ·001", reaching the median line. E. Infus. p. 176; EM. many figures. Europe, Asia, Africa, America, Lough Mourne deposit. 1-1500" to 1-560".

N. *oxyptera* (K.).—Elongated, slender, narrow-lanceolate, with acute apices, and fine, slightly radiant, transverse striæ. KSA. p. 69. = *Pinnularia amphioxys*, EM. many figures; *P. acuta*, SD. i. p. 56, pl. 18. f. 171. Europe, Asia, Australia, Africa, America.

N. *Kefvingensis* (E.).—Small, striated, lanceolate, navicular; striæ converging at the centre, 17 in 1200". EB. 1840, p. 20. = *Pinnularia Kefvingensis*, EM. pl. 10. 2. f. 4, 5. Fossil. Bohemia, Asia.

N. *peregrina* (E., K.).—Striated, narrow-lanceolate, gradually tapering to the subacute apices; pinnules oblique, reaching the median line, 13 in ·001". KB. p. 97, pl. 28. f. 52. = *Pinnularia peregrina*, EA. p. 133, several figures; SD. i. p. 56, pl. 18. f. 170. Marine. Europe, Asia, Africa, America.

N. *leptostigma* (E.). — Striated, lanceolate, with subacute, slightly produced apices; the transverse dotted striæ inconspicuous. EB. 1845. = *Pinnularia leptostigma*, EM. pl. 33. 12. f. 25. Fossil. United States. Twice as long as broad. 1-432".

N. *Ehrenbergii* (K.).—Lanceolate, with somewhat acute apices, and fine, radiating striæ. KB. p. 92, pl. 3. f. 38. = *Navicula lanceolata*, E. Inf. pl. 13. f. 21. Europe.

N. *neglecta* (K.).—Turgid, lanceolate, with subacute apices, margins longitudinally costate and transversely striated. KB. p. 92, pl. 28. f. 44. = *Pinnularia lanceolata*, EA. pl. 3. 1. f. 6. Europe, America. Front view oblong, with incrassated middle and truncate ends. 1-1150" to 1-280"; striæ 13 in 1-1200".

N. *Sempronia* (Perty). — Minute, acutely lanceolate; striæ not reaching the median line, front view linear, slightly narrowed towards the ends. Perty, Microsc. Org. p. 204, pl. 17. f. 8. Alps. Belongs to the smaller species, and is very like *N. exilis*.

N. *directa* (S.). — Slender, narrow-lanceolate, acute; costæ fine, parallel, reaching the median line, 20 in ·001". = *Pinnularia directa*, SD. i. p. 56, pl. 18. f. 172. Marine. Sussex. Front view narrow-linear.

N. *pulchra* (Greg.).—Broadly lanceolate or somewhat rhomboid; striæ radiant, strongly moniliform, nearly reaching the median line, shorter opposite the slightly dilated indefinite nodules. TM. iv. p. 42, pl. 5. f. 7. Marine. Scotland. Rapidly tapering to the obtuse apices.

N. *longa* (Greg.).—Much elongated, lanceolate or slightly rhomboid, acute; costæ conspicuous, about 12 in ·001", nearly reaching the median line, somewhat shorter and radiant opposite the central nodule. = *Pinnularia longa*, Greg. TM. iv. p. 47, pl. 5. f. 18. Scotland. The only known form to which it has any resemblance is *N. directa*, but the latter form is not rhombic, and the striæ are much more numerous and parallel.

N. *acutiuscula* (Greg.). — Elongated, slender, linear-lanceolate, acute; costæ distinct, about 30 in ·001", reaching the median line, central ones radiant and more conspicuous. = *Pinnularia acutiuscula*, TM. iv. p. 48, pl. 5. f. 21. Scotland.

N. *costata* (K.). — Oblong-lanceolate, with obtuse apices, and longitudinal punctated lines; median nodule large, terminal ones minute. KB. p. 93, pl. 3. f. 56. Fossil. Santa Fiore. Front view oblong, with broadly rounded apices.

N. *Norregica* (E., K.).—Broadly oblong, with acute apices, a narrow striated border, and a smooth median space; striæ 30 in 1-1200". KA. p. 79. = *Pinnularia Norvegica*, E. Marine. Europe. Front view narrow-linear, truncate. 1-360".

N. *Libyca* (E.). — Small, striated, acutely oblong-lanceolate, with 14 striæ in 1-1200"; front view quadrangular, with truncate ends. EB. 1840, p. 20. Sinai. 1-550". It has the habit of *N. fulva*, but is wider, and not rostrate.

N. *Pupula* (K.). — Minute, smooth, oblong-lanceolate, with slight produced apices. KB. p. 93, pl. 30. f. 40. Europe.

N. *alpina* (S.). — Large, oblong-lanceolate, with obtuse ends, and 7 to 9 stout, distant, radiant costæ in ·001", which do not reach the median line. = *Pinnularia alpina*, SD. i. p. 55, pl. 18. f. 168. France, Scotland. Front view broadly linear, with truncate ends; costæ shorter near the central nodule.

N. *distans* (S.). — Lanceolate, with subacute apices; costæ radiant, distant, 10 in ·001", not reaching the median line. = *Pinnularia distans*, SD. i. p. 56, pl. 18. f. 169. Marine. Common, especially from deep dredgings. Costæ shorter opposite the central nodule.

N. *elegans* (S.). — Broadly or elliptic lanceolate, with slightly acuminated ends; striæ distinct, 24 in ·001", waved, radiate, nearly reaching the median line, shorter opposite the central nodule. SD. i. p. 49, pl. 16. f. 137. Marine. England.

N. *permagna* (Bai.). — Large, turgid-lanceolate, with obtuse apices, a marginal band of punctated striæ, and a broad, lanceolate, longitudinal median blank space; nodule indefinite. = *Pinnularia permagna*, BMO. p. 40, pl. 2. f. 28 & 38. United States.

II. *Valves linear or oblong, neither rostrate nor constricted.*

† Ends scarcely cuneate.

N. *Bacillum* (E.).—Linear, with truncate, rounded ends; striæ indistinct, 54 in ·001". EM. several figures. = *N. bacillaris*, Greg. MJ. iv. pl. 1. f. 24. Ehrenberg gives about 50 habitats in Europe, Asia, Australia, Africa, and America.

N. *borealis* (E., K.).—Small, striated, linear, with slightly attenuated, rounded apices; striæ stout, rather distant, not reaching the median line, 13 in ·001". KB. p. 96, pl. 28. f. 68–72. = *Pinnularia borealis*, EM. numerous figures; *Pinnularia latestriata*, Greg. MJ. ii. pl. 4. f. 13. (VII. 74.) A very common and widely diffused species. Ehrenberg gives about 200 habitats for it. *β* longer and more dilated at the middle, = *Pinnularia Caraccana*, E. Under moss on trees. The front view of this species is linear, with truncated ends and striated margins, and resembles that of detached frustules of Denticula and Odontidium.

N. *Chilensis* (E., K.).—Large, linear, with broadly rounded apices, and 11 or 12 stout costæ in 1-1200". KA. p. 79. = *Pinnularia Chilensis*, EM. pl. 34. 11. f. 3. Australia, Asia, Africa, America. (XII. 33.) Costæ parallel, equal. Approaches to *N. viridis*, but is shorter and broader.

N. *rectangulata* (Greg.).—Linear, with truncate rounded ends; costæ rather distant, 22 in ·001", nearly reaching the median line, except opposite the dilated indefinite nodule, and there shorter and diverging. GDC. p. 7, pl. 1. f. 7. Marine. Scotland.

N. *Iridis* (E.). — Large, elongated, linear-oblong, tapering into the obtuse apices, finely striated both longitudinally and transversely, iridescent. EA. p. 130, pl. 4. 1. f. 2. New York.

N. *oblonga* (K.).—Elongated, slender, oblong or linear-oblong, with rounded apices; costæ stout, connivent at the centre. KB. p. 97, pl. 4. f. 21. = *Pinnularia polyptera*, EA. p. 133; *P. macilenta*, E. Common. We follow Kützing and Smith in referring *P. macilenta*, E., to this species; Ehrenberg's figures, however, differ from theirs in being more linear, with less tapering apices. 1-140".

N. *Oregonica* (E., K.). — Elongated, bacillar, uniformly and gradually decreasing towards the rounded apices; pinnules stout, 23 in 1-1152". KA. p. 71. = *Pinnularia Oregonica*, EB. 1845, p. 79. Fossil. Oregon. 1-228". It approaches to *N. Digitus*, but is more slender.

N. *truncata* (K.). — Minute, smooth, linear, with truncato-rounded ends, and an inner marginal border twice constricted; front view broadly linear, truncate. KB. p. 96, pl. 3. f. 34. Europe.

N. *Liber* (S.).—Linear-oblong, with rounded apices, and 48 delicate striæ in ·001"; colour of dry valve purplish. SD. i. p. 48, pl. 16. f. 133. Marine. Sussex.

N. *Stylus* (E.). — Elongated, narrow-linear, with rounded ends, and having longitudinal dotted lines on each side. EM. pl. 15 A. f. 36. Asia; Lough Mourne deposit.

N. *Ergadensis* (Greg.).—Rather small, narrowly linear-oblong, with rounded ends; costæ distinct, 25 in ·001", nearly reaching the median line, shorter and radiant opposite the roundish, smooth umbilical space. = *Pinnularia Ergadensis*, TM. iv. p. 48, pl. 5. f. 22. Scotland.

N. *styliformis* = *Pinnularia styliformis*, EM. pl. 38 A. 17. f. 6. Australia, Africa, America. Ehrenberg's figure represents a portion of an elongated, narrow, strictly linear valve, with rhomboid ends, and fine, parallel striæ which reach the median line.

N. *Dactylus* (E., K.).—Large, elongated, linear-oblong, passing by a very gentle curve into the slightly narrower, broadly rounded apices; pinnules 14 in 1-1200". KB. p. 98, pl. 28. f. 59. = *Pinnularia Dactylus*, EA. p. 132, pl. 4. 1. f. 3. Europe, Asia, Africa, America. Lough Mourne deposit.

N. *viridis* (Nitzsch, K.).—Elongated,

slender, linear-oblong or linear lanceolate, with obtuse apices; 12 to 14 radiant costæ in 1-1200″, shorter opposite the central nodule. KB. p. 97, pl. 4. f. 18. = *Pinnularia viridis*, E., in part? ; *Navicula viridula*, E. (IX. 133-136.) Common. 1-3000″ to 1-280″.

N. *hemiptera* (K.).—Narrow, linear-oblong, with obtuse, conic apices, and 14 or 15 radiant costæ in 1-1200″, which do not reach the median line. KB. p. 97, pl. 30. f. 11. = *Pinnularia hemiptera*, SD. ii. p. 95. America, Europe. Front view linear, with rounded angles. Often overlooked from its resemblance to *N. viridis*, from which it is distinguished by its finer striæ and narrower valve.

N. *æquinoctialis* (Mont.). — Rather large, linear-oblong, with rounded apices, and 4 stout, radiant pinnules in 1-2600″. Montague, Annales des Sciences Nat. 1850, p. 309. Guiana. 1-260″ to 1-150″. In form it resembles *N. Dactylus*, but differs in its size and much larger striæ. In the latter respect it approaches to *N. pachyptera*, but has not the median inflation of that species.

N. *pleurophora* (K.).—Large, stout, oblong, or linear-oblong, with broadly rounded ends, and 6 stout costæ in 1-1200″. KA. p. 79. = *Pinnularia costata*, EM. pl. 4. 2. f. 5; *Pinnularia megaloptera*, EM. pl. 3. 1. f. 4. America, Asia.

N. *Suecica* (E.).—Oblong-elliptic, with broadly rounded ends, short, stout, rather distant marginal costæ, and large central blank space. E Inf. p. 189, t. 21. f. 18. = *Pinnularia Suecica*, EM. Fossil. Sweden.

N. *lata* (Bréb.).—Large, linear-oblong, with rounded apices, and 8 stout costæ in ·001″, which do not reach the median line, and are shorter and somewhat connivent opposite the central nodule. KA. p. 79. = *Pinnularia lata*, SD. i. p. 55, pl. 18. f. 167. France, Britain. Front view very broad linear, with rounded angles, truncate ends, and striated margins; the central nodules large. This species approaches closely in character to *N. Suecica*.

N. *Digitus* = *Pinnularia Digitus*, EM. pl. 33. 8. f. 15; pl. 38 A. 3 B. f. 1. America, Java. This species is figured as large, linear-oblong, with broadly rounded ends, and stout, parallel costæ which do not reach the median line.

N. *Dux* = *Pinnularia Dux*, EM. pl. 8. 2. f. 5. Fossil. Hungary. Ehrenberg represents it as large, elliptic-oblong, with rounded ends and divergent costæ, which do not reach the median line, and are shorter opposite the central nodule.

N. *ostrearia* (K.). — Small, elliptic-oblong, with rounded ends, large central nodule, and close, fine striæ. KA. p. 77. Marine. France.

N. *retusa* (Bréb.).—Striated, narrow-linear, with rounded ends; front view broad, quadrate, with rounded angles, truncate ends, and concave and striated lateral margins. Bréb DC. p. 16, pl. 1. f. 6. Marine. Europe. The frustules are much compressed; and consequently the front view is so much broader than the lateral surfaces, that it is difficult to obtain a good sight of the latter. *N. retusa*, *N. apiculata*, and a few allied species probably ought, as suggested by M. de Brébisson, to form a separate group, if not a distinct genus, distinguished by the great comparative breadth of its front view, with its striated and sinuated or constricted lateral margins.

N. *scita* (S.).—Nitescent, linear-oblong, with attenuated, obtuse ends; striæ very faint, 45 in ·001″; nodule small. ANH. 1857, xix. p. 8, pl. 2. f. 4. Pyrenees.

N. *parvula* (Greg.).— Small, narrow linear-lanceolate, with obtuse ends and distinct costæ, which do not reach the median line. = *Pinnularia parva*, MJ. ii. p. 98, pl. 4. f. 11. Mull.

2† Valves linear or oblong, with cuneate ends.

N. *amphigomphus* (E.). — Large, broadly linear, with sharply cuneate ends, with or without obscure longitudinal lines; striæ obsolete or distinct. EA. p. 129, pl. 3. 1. f. 8; EM. many figures. America, Asia, Europe. Lough Mourne deposit. β, striæ distinct. = *Pinnularia amphigomphus*, EM. pl. 14. f. 11. Cayenne, France.

N. *dilatata* (E.).—Large, oblong or broadly linear, with obtuse, cuneate ends, and furnished with longitudinal lines near the margins. EM. many figures. Europe, Lough Mourne.

N. *disphenia* (E., K.). — Linear, elongated, with sharply cuneate ends, finely striated near the margins. KB. p. 93, pl. 28. f. 54. = *Pinnularia disphenia*, EA. p. 132. America, Australia. Approaches to *N. amphigomphus*.

N. *acuta* (K.).—Narrow-linear, smooth, with acute, shortly cuneate apices. KB. p. 93, pl. 3. f. 49. Island of Wangerooge, Australia.

N. *subacuta* = *Pinnularia subacuta*, EM. pl. 35 A. 6. f. 12. Perth, Australia. Ehrenberg's figure represents this species as linear, with cuneate apices, fine, close, parallel striæ, which reach the median line, and a small central nodule.

N. *acuminata* (S.). — Linear, with acutely cuneate ends and parallel costæ, which do not reach the median line. = *Pinnularia acuminata*, SD. i. p. 55, pl. 18. f. 164. Premnay peat.

N. *minor* (Greg.). — Minute; lateral view linear, with acutely cuneate ends; striæ fine, nearly parallel, not reaching the median line, 36 to 40 in ·001″. GDC. p. 5, pl. 1. f. 1. Scotland.

N. *crassa* (Greg.).—Linear- or elliptic-oblong, with obtusely cuneate ends; striæ fine, but distinct, moniliform, radiant, nearly reaching the median line, but leaving an orbicular blank space round the central nodule. MJ. iii. p. 41, pl. 4. f. 18. Scotland. Is of a brown colour in balsam.

N. *Utriculus* (E., K.). — Striated, linear-oblong; ends attenuated, with a slight marginal curvature, into the obtuse apices. KB. p. 93. = *Pinnularia Utriculus*, EA. p. 134. Mexico. Akin to *N. disphenia.*

N. *trigonocephala* (E.). — Striated, linear, with the ends dilated into large cuneate heads. = *Pinnularia trigonocephala*, EM. pl. 34. 8. f. 11. Japan. Very unlike any other species in having the cuneate heads much dilated and broader than the intermediate portion.

N. *microstoma* (K.).—Large, turgid, elongated oblong, with obtusely cuneate ends, longitudinal lines, and a very minute oblong median nodule; striæ numerous, obscure. KA. p. 71. = *N. lata*, KB. p. 92, pl. 3. f. 51; *N. firma*, SD. p. 48, pl. 16. f. 138. Europe. Front view broadly linear, with truncate ends, rounded angles, and broad lateral borders, turgid at the middle. Perhaps Professor Smith was right in uniting this to *N. firma*.

N. *firma* (K.).—Large, turgid, oblong-lanceolate, with obtuse, cuneate ends, thick borders, and large median nodule; striæ wanting or obscure. KB. p. 92, pl. 21. f. 10. Fossil. Santa Fiore.

N. *maxima* (Greg.).—Large, striated, linear, with longitudinal lines, and obtuse, cuneate or conic ends; striæ fine, parallel, nearly reaching the median line, shorter opposite the central nodule, about 52 in ·001″. GDC. p. 15, pl. 1. f. 18. Marine. Britain. (VII. 75.) Generally elongated; nodule definite, surrounded by a smooth space. Front view linear, narrowest at the middle, with striated margins. Differs from *N. firma* in its paler colour, finer striæ, and more obtuse apices, Greg.

N. *formosa* (Greg.).—Large, striated, linear or linear-oblong, with longitudinal lines, obtuse, cuneate or conic ends; striæ distinct, slightly inclined, not reaching the median line, shorter opposite the large central nodule, about 35 in ·001″. TM. iv. p. 42, pl. 5. f. 6. Marine. Scotland. Agrees in form with *N. maxima*, but is distinguished by its more conspicuous and slightly inclined striæ which do not reach the median line, leaving a longitudinal median blank band.

N. *Kerguelensis* (R.). — Oblong, with obtusely cuneate ends; costæ stout, radiant; nodule indefinite. = *Pinnularia Kerguelensis*, EM. pl. 35 A. 2. f. 15. Africa.

I. *Valves elliptic, with rounded ends.*

N. *cocconeoides* (Rab.). — Small, elliptic, with broadly rounded ends, and 11 to 13 parallel and distinct, but faint striæ in 1-1200″, which reach the median line. = *Pinnularia cocconeoides*, Rab D. p. 43, pl. 6. f. 18. Stockholm.

N. *scutelloides* (S.). — Small, suborbicular, with 18 moniliform, radiant striæ in ·001″, nearly reaching the median line. SD. ii. p. 91; Greg. MJ. iv. pl. 1. f. 15. Britain.

N. *pectinalis* (Bréb.).—Linear-elliptic, with rounded ends, and 22 striæ in ·001″. SD. ii. p. 92. Marine. France, Britain. Front view with truncate ends.

N. *Algeriensis* (Mont.).—Elliptic-oblong, with 10 striæ on each margin. M. Fl. d'Algér. p. 190. Marine. Algiers.

N. *Cluthensis* (Greg.).—Elliptic, with broadly rounded ends; striæ conspicuous, moniliform, reaching the median line, about 20 in ·001″; median line broadest at the central nodule, slightly attenuated towards the ends. GDC. p. 6, pl. 1. f. 2. Scotland. (VII. 73.)

N. *ovalis* (Näg.). — Finely striated, oval elliptic; front view broadly linear. 1-720″ to 1-600″. KA. p. 890. Switzerland.

N. *oblongella* (Näg.). — Smooth, oblong-oval; front view broadly linear. 1-720″ to 1-430″. KA. p. 890. Switzerland.

N. *fossilis*, EM. pl. 10. 1. f. 6. Bohemia. Ehrenberg's figure shows this species elliptic, slightly rhomboid, with rounded ends; the median suture of three lines, interrupted by the indefinite central nodule.

N. *nana* (Greg. *MS.*).—Minute, oval, obtuse; costæ radiant, nearly reaching the median line; umbilical space not dilated. = *Pinnularia pygmæa*, EM. pl. 10. 1. f. 9; MJ. iv. pl. 1. f. 8. Europe.

N. *lepida* (Greg.).—Minute, hyaline, oval, or oblong, with obtuse ends; striæ indistinct from their transparency, slightly radiant. MJ. iv. p. 7, pl. 1. f. 25. Scotland.

N. *oceanica.* — Elliptic-oblong, twice as long as broad, with subacute apices, small, round, clearly-defined umbilicus, and double median line; margin delicately but widely striated; pinnules 20 in 1-1200″. Southern Ocean. 1-570″.

K. *Median line flexuose.*

N. *tumida* (Bréb.). — Large, tumid, striated, twisted, oblong, with obtuse apices, a flexuose median line, and close, fine striæ, which reach the median line. KA. p. 77.=*N. Jennerii*, SD. i. p. 49, pl. 16. f. 134. Marine. France, Britain. (VII. 55.) Front view broad linear oblong, with rounded angles; frustules twisted, so that the hyaline central portion appears flexuose.

N. *convexa* (S.).—Large, tumid, striated, twisted, linear oblong, with conic apices, a flexuose median line, and 21 striæ in ·001″, which do not quite reach the median line. SD. i. p. 49, pl. 18. f. 136. Marine. England. Front view broadly linear-oblong, with rounded angles, and a narrow, flexuose, longitudinal median band.

N. *Westii* (S.).—Broadly lanceolate, with subacute apices, and 38 delicate striæ in ·001″, which nearly reach the slightly flexuose median line. SD. i. p. 49, pl. 16. f. 135. Marine. England. Colour of dry valve dark purple; front view linear, with rounded angles, and a narrow, slightly flexuose median band.

N.? *campylogramma* (E.). — Small, ovate, obtuse, smooth, with a flexuose, sigmoid median line, and orbicular central nodule. EB. 1853, p. 36. Bavaria, Rhine. Probably identical with *Achnanthidium flexellum*, since Ehrenberg states that he has seen it, together with *Achnanthes? Bavarica*, distributed under the name of *Cymbella flexella*.

N. *tortuosa* (E.).—Smooth, crystalline, rather turgid, and somewhat tortuous, so that one end has a more obtuse apex. EB. 1843, p. 271. 1-288″.

N. *dissimilis* (S.).—Frustules oblique; elliptic; median line somewhat diagonal from the obliquity of the frustule, recurved at extremities; striæ obscure. ANH. 1857, xix. p. 8, pl. 2. f. 6. Pyrenees.

L. *Frustules lunately curved in the front view.*

N. *genuflexa* (K.).—Parasitic, smooth, narrow-lanceolate, obtuse; front view linear, with truncate ends, lunately curved. KB. p. 101, pl. 21. f. 6. Marine. Peru.

M. *Frustules lunately curved in the lateral view.*

N. *Neapolitana* (Rab.). — Lunately curved, linear, with truncate ends, and transverse striæ. = *Falcatella Neapolitana*, Rab D. p. 46, pl. 5. f. 3. Italy.

N. *lunata* (K.).—Smooth, small, lunately curved, narrow-linear, with slightly rounded ends; front view linear, truncate. KB. p. 101, pl. 4. f. 1. 4.=*Falcatella lunata*, Rab D. p. 46. Italy.

N. *Romana* (Rab.).—Smooth, attached by a gelatinous base; lunately curved, linear, with truncate ends; front view linear lanceolate, truncate. = *Falcatella Romana*, Rab D. p. 46, pl. 5. f. 1. Italy.

Doubtful or insufficiently described Species.

N. *varians* (Greg.).—Form and size variable; striæ oblique, 14 to 18 in ·001″, nearly reaching the median line, more conspicuous opposite the central nodule, and highly radiant. TM. iii. p. 12, pl. 2. Britain. In this species Professor Gregory disregarded form and size, considering the number and disposition of the striæ as the essential characters.

N. *mutabilis* (Greg.).—Form and size variable; striæ as in *N. varians*, but finer, and from 24 to 26 in ·001″. TM. iii. p. 14.=*Pinnularia exigua*, MJ. ii. pl. 4. f. 14. Britain. We concur in opinion with the late Professor Smith, that these species are too vaguely defined, and that probably they are constituted of forms belonging to various other species.

N. *minutissima* (Rab.).—Exceedingly minute, but with distinct median nodule. Rab D. p. 39, pl. 6. f. 80. Persia.

N. *megalodon* = *Pinnularia megalodon*, EM. pl. 33. 14. f. 21. America. The central portion of a large, oblong species, with stout, distant, parallel costæ, which do not reach the median line.

N. *omphalia* (E.).—Large, iridescent, with very fine, granulated, decussating lines; umbilicus orbicular, solid, hyaline, divided by the straight median line. Fossil. Fragments in Bermuda deposit.

N. *Rhaphoneis* = *Pinnularia Rhaphoneis*, EM. pl. 35 A. 9. f. 7. Ganges. Minute, oblong, with subacute apices, a small central nodule, and diverging striæ.

N. *eurysoma* (E.).—Minute, smooth, elliptic, with rounded ends, and marked by two narrow, longitudinal blank lines, which converge at each end and are connected at the centre by the transverse nodule. EB. 1838. = *Stauroneis eurysoma*, EM. pl. 21. f. 36. Fossil. Algiers. Apparently more allied to the lyrate group of Navicula than to Stauroneis.

Species from Ehrenberg, known to us only by name.

N. *ceratostigma*, *N. Jordani*, *N. Legumen*, *N. amphilepta*, *N. obliqua*, *N. turgida*, *N. Senegalensis*, *N. Falklandiæ*, *N. Catharinæ*, *N. conspersa*, *N. Savannæ*, *N. aulacophæna*, *N. Barbadensis*, *N. Euryale*, *N. leptoceros*, *N. sphæroptera*, *N. Vibrio*, *N. leptotermia*.

Pinnularia affinis, Ehrenberg gives 30 habitats. It may be a form of *Navicula affinis*, with more evident striæ.

P. *ambigua*, *P. australis*, *P. insularis*, *P. pleuronectes*, *P. Preissii*, *P. Fusus*, *P. Rhenana*, *P. Craticula*, *P. pteropharna*, *P. platysoma*, *P. Catharinæ*, *P. anomala*, *P. Hemprichii*, *P. Licuaræ*, *P. Capensis*, *P. Caffra*, *P. antarctica*, *P. Folium*, *P. microsphenia*, *P. pleuronectes*, *P. Araucaniæ*, *P. Barbadensis*.

Genus STAURONEIS (Ehr., Kütz.).—Frustules simple, free in front view parallelogramic; valves with median line and nodules, central nodule transversely dilated. Stauroneis differs from Navicula in having the central nodule prolonged into a transverse pellucid band (stauros) free from striæ. "In a few cases we meet with the semblance of a stauros in the genus Pinnularia [Navicula]; but in these instances a closer examination will show that this appearance arises from the interruption of the costæ merely, and not from the dilatation of the central nodule, which is still found unchanged" (Smith). Ehrenberg divides this genus into Stauroneis and Stauroptera—the former having smooth, and the latter striated frustules; but we agree with Professor Kützing in thinking the distinction, as in Navicula and Pinnularia, unsatisfactory, and that many species would be referred by the observer to the one or other genus according to the magnifying power of the microscope used in the examination.

* *Valves constricted at the centre.*

STAURONEIS *constricta* (E.).—Small, oblong, deeply constricted at the centre, and slightly contracted into obtuse apices. EA. p. 134, pl. 1. 2. f. 12 *b*. Chili, Australia, Africa.

S. *Rabenhorstii*.—Linear, with broadly rounded ends and concave sides; costæ stout, oblique; stauros linear. = *Stauroptera constricta*, Rab D. p. 50, pl. 9. f. 10. Italy.

2* *Valves with* 2 *or* 3 *undulations.*

S. *inflata* (K.).—Small, linear, with two constrictions, and three dilatations; ends broadly rounded; stauros linear, reaching the margin. KB. p. 105, pl. 30. f. 22. Trinidad. 1-480" to 1-428".

S. *Fulmen* (Bréb.).—Lanceolate, acute, with two undulations; stauros very slightly dilated towards the margin; striæ distinct, 22 in ·001"; front view rectangular. ·008" to ·015". TM. vii. p. 180, pl. 9. f. 6. Fresh water. Melbourne. This beautiful species resembles *S. acuta*, but is easily distinguished by its marginal undulations.

S. *Legumen* (E.). — Small, oblong-lanceolate, each margin with three undulations; apices apiculated; stauros linear, reaching the margin. EB. 1844, p. 135; EM. pl. 39. 3. f. 104; Greg. MJ. iv. pl. 1. f. 9. = *Stauroneis linearis*, SD. i. p. 60, pl. 19. f. 193. America, Europe. (VII. 67.)

3* *Valves with a sigmoid median line.*

S. *Sigma* (E.). — Stout, lanceolate, sigmoid, with obtuse apices; stauros abbreviated. EB. 1844, p. 88; EM. pl. 18. f. 63. Fossil. Richmond deposit. It has the form and size of *Pleurosigma acuminatum*; but its median nodule is dilated, as if geminate. 1-240". Ehr.

S. *obliqua* (Greg.). — Small, short, oblong, or broadly lanceolate, with a sigmoid or oblique median line; stauros reaching the margin; striæ fine, 45 in ·001". MJ. iv. p. 10, pl. 1. f. 35. Lochleven. (VII. 63.)

4* *Valves with rostrate or capilate apices.*

S. *dilatata* (E.).—Small, ventricose, with minute, mammiform beaks; stauros linear, nearly reaching the margin. EA. pl. 1. 2. f. 12*a*; SD. i. p. 60, pl. 19. f. 191. America, Australia. (XII. 16.)

S. *exilis* (K.). — Very minute, ventricose, shortly rostrate; stauros linear. KB. p. 105, pl. 30. f. 21. Trinidad. 1-2400″.

S. *punctata* (K.). — Small, ventricose, with rostrate apices, and 27 radiant punctate striæ in ·001″; stauros linear, abbreviated. KB. p. 106, pl. 21. f. 9; SD. i. p. 61, pl. 19. f. 189. Britain. Fossil, Santa Fiore.

S. *anceps* (E.). — Small, lanceolate, constricted beneath the subcapitate apices; stauros linear, not reaching the margin; striæ very delicate, 45 in ·001″. EA. p. 134, pl. 2. 1. f. 18; SD. i. p. 60, pl. 19. f. 190. Europe, Asia, Africa, America.

S. *Crucicula* (S.). — Small, elliptic-lanceolate, somewhat ventricose, produced at the ends into minute, conical beaks; stauros very narrow, linear, reaching the margin. SD. i. p. 60, pl. 19. f. 192. Marine. Ireland. (VII. 64.)

S. *ventricosa* (K.). — Very minute, ventricose, constricted beneath the capitate apices; stauros linear, not reaching the margin. KB. p. 105, pl. 30. f. 27. Germany, France, Britain.

S. *capitata* (E.).—Very small, oblong, twice as long as broad, suddenly constricted beneath the capitate apices; striæ 18 in 1-1560″. EB. 1844. Southern Ocean. Front view linear. 1-1152″.

S. *phyllodes* (E.).—Turgid-lanceolate, with the apices produced into short, subacute beaks; stauros linear, reaching the margin. EA. p. 135, pl. 1. 2. f. 10. America, China. (XII. 7-9.)

S. *Semen*, EM. pls. 35 A, and 38 A. many figures. Ehrenberg gives about 80 habitats in Asia, Africa, and America. Lateral view small, ventricose, with mammiform apices and linear stauros.

S. *Tuscula* (E.). — Small, striated, elliptic-oblong; apices suddenly contracted, umbonate; stauros linear, reaching the margin; striæ oblique. = *Navicula Tuscula*, EB. 1840, p. 21; KA. p. 77; *Stauroptera Tuscula*, EM. pl. 6. 1. f. 13. Fossil. Santa Fiore, Siberia. Front view linear.

S. *mesopachya*, EM. pl. 15 A. f. 26. Lough Mourne deposit. Large, oblong-lanceolate, suddenly contracted into mammiform, obtuse apices; stauros linear.

S. *birostris* (E.). — Small, narrow-lanceolate, with produced, rostrate, subacute apices; stauros linear. EA. p. 134, pl. 2. 2. f. 1. America, Africa.

S. *Platalea* (E.).—Lateral view slender lanceolate, constricted beneath the capitate apices; stauros linear. EM. pl. 15 A. f. 30. Lough Mourne deposit; Mexico.

S. *Sieboldii* (E.). — Large, turgid-lanceolate, tapering into obtuse beaks; stauros linear. EM. pl. 34. 8. f. 12. Japan.

S. *Ehrenbergii* (E.). — Small, inflated, oval, with produced, mammiform apices; stauros linear; striæ parallel. = *Stauroptera platystoma*, EM. pl. 14. f. 13. Berlin.

S. *platystoma* (E., K.).—Linear-oblong, contracted at the ends into mammiform beaks; stauros linear. KB. p. 105, pl. 3. f. 58; EM. pl. 3. 1. f. 8. = *Navicula platystoma*, E Inf. pl. 13. f. 8. Germany, America, Asia. (IX. 142.) 1-1100″ to 1-240″.

S. *amphicephala* (K.).—Linear-oblong, with produced, rostrate, capitate apices; stauros linear. KB. p. 105, pl. 30. f. 25. Germany, France.

S. *linearis* (E.). — Minute, linear-oblong, with parallel marginal lines, attenuated at the apices into somewhat obtuse beaks; stauros linear. EA. p. 135, pl. 1. 2. f. 11. America, Europe. Lough Mourne deposit.

S. *macrocephala* (K.).—Linear, slender, constricted beneath the capitate apices; transverse striæ very dense. KA. p. 92. = *Stauroptera macrocephala*, Rab D. p. 49. France. 1-425″.

S. *platycephala* = *Stauroptera platycephala*, EM. pl. 17. 2. f. 9. Fossil. Finland. Linear, suddenly constricted beneath the dilated, broadly rounded ends; stauros linear, reaching the margin; striæ parallel.

S. *excellens* (Perty).—Striated, broadly linear, suddenly contracted into broadly rounded, mammiform beaks. Perty, Inf. p. 205, t. 17. f. 11. Alps. Form and size of *S. platystoma*, but striated. Its nearest ally is *S. microstauron*, E.; but it is larger and somewhat broader, with less broadly rounded ends.

S. *microstauron* (E., K.). — Striated, linear, suddenly constricted beneath the broadly rounded, subcapitate apices; stauros linear. KB. p. 106, pl. 29. f. 13. = *Stauroptera microstauron*, EA. pl. 1. 4. f. 1. Asia, Africa, America.

S. *monogramma* (E.).—Oblong, turgid at the middle, and contracted at each end into a broad, rounded, conical beak. EA. p. 135; KB. p. 105, pl. 29. f. 18. Surinam. Resembles *Achnanthes ventricosa*.

S. *granulata* (E.). — Bacillar, with turgid middle and obtuse ends; transverse striæ granulated. = *Stauroptera granulata*, EB. 1847, p. 484. Canton. 1-480″. Allied to *Fragilaria? mesotyla*, and to *Achnanthes ventricosa.*

5* *Valves neither constricted, rostrate, nor furnished with a sigmoid median line.*

† Valves lanceolate.

S. *Phœnicenteron* (Nitzsch., E.). — Large, broadly lanceolate or somewhat rhomboid, gradually attenuated into rather obtuse apices; stauros slightly dilated outwards, reaching the margin; striæ fine. EA. pl. 2. 5. f. 1; SD. i. p. 59, pl. 19. f. 185. = *Bacillaria Phœnicenteron*, Nitzsch; *Cymbella Phœnicenteron*, AD. p. 10; *Navicula Phœnicenteron*, E Inf. Common. Europe, Asia, Africa, America. (IX. 139; XII. 17, 18.) 1-400″ to 1-140″.

S. *pteroidea* (E.).—Large, broadly or sharply lanceolate, with obtuse apices, and very fine, punctated, transverse striæ; stauros linear, reaching the margin. EA. p. 135; EM. pl. 3. 3. f. 7. America. Akin to *S. Baileyi*; larger than *S. Phœnicenteron*, E.

S. *Baileyi* (E.).—Large, broadly lanceolate, tapering gradually to the obtuse apices; surface with very fine longitudinal, undulated lines; stauros linear, reaching the margin. EA. p. 134; EM. several figures. America. Akin to *S. Phœnicenteron* and *S. pteroidea*, E.

S. *amphilepta* (E.).—Lanceolate, little acuminated, with obtuse apices; stauros linear; striæ none, or indistinct. EA. pl. 1. 2. f. 9-13. America, Africa, Siberia. It is scarcely distinct from *S. Phœnicenteron.*

S. *gracilis* (E.). — Slender-lanceolate, gradually attenuated into obtuse apices; stauros linear, scarcely reaching the margin; striæ indistinct, very delicate. EA. pl. 1. 2. f. 14; SD. i. p. 59, pl. 19. f. 186. America, Europe, Asia, Africa. Smaller and more slender than the preceding species.

S. *apiculata* (Grev.).—Oval, obtusely apiculate; stauros linear, abbreviated; striæ fine, 34 in ·001″. Edin. New Phil. Journ., n.s., x. pl. 4. f. 8. Californian guano. Inflated, suddenly contracted at the ends into conic beaks; stauros not reaching more than half way from the median line to the margin.

S. *lanceolata* (K.). — Slender-lanceolate, tapering into the narrow, subrostrate ends; stauros linear, reaching the margin; striæ obsolete or indistinct. KB. p. 104, pl. 30. f. 24. Falaise. 1-180″ to 1-160″.

S. *Atlantica* (E.).—Small, lanceolate, with obtuse apices; front view linear. EB. 1845, p. 155. In pumice from the Isle of Ascension. Akin to *S. amphilepta*, but more obtuse. 1-1152″.

S. *salina* (Sm.).—Small, slightly contracted at the obtuse apices; stauros linear, nearly reaching the margin; striæ faint, 45 in ·001″. SD. i. p. 60, pl. 19. f. 188. Marine. Britain.

S. *minuta* (K.).—Smooth, lanceolate, rather obtuse, three times as long as broad. KA. p. 89. Thuringia. 1-1200″.

S. *dubia* (Greg.). — Minute, smooth, narrow-lanceolate, with somewhat truncate apices; stauros linear, nearly reaching the margin. MJ. iv. p. 11, pl. 1. f. 37. Scotland. When examined under a high power, the valve exhibits two parallel lines within the margin on each side.

S. *staurophœna* (E.). — Lanceolate, smooth, slightly contracted at the subacute apices; stauros linear, not reaching the margin. EA. p. 135; EM. pl. 2. 3. f. 11. North America. Distinguished from *S. Phœnicenteron* by its abbreviated stauros.

S. *Gregorii* (Ralfs).— Rhomboid-lanceolate, with acute apices; stauros linear, reaching the margin; striæ fine, nearly parallel, 60 in ·001″. = *Stauroneis amphioxys*, Greg. TM. iv. p. 48, pl. 5. f. 23. Scotland. Highly convex, and even in the best position showing the margin as a broad black line, Greg.

S. *inanis* (Perty).—Striated, lanceolate or elliptic-lanceolate, with very fine transverse striæ. Perty, Inf. p. 206, pl. 17. f. 7. Alps. In form nearly agreeing with *S. linearis*, E., but striated.

S. *lineolata* (E.).—Broadly lanceolate, with obtuse apices, and parallel, dotted, longitudinal lines; stauros linear. EA. p. 135, pl. 2. 1. f. 19. Cayenne.

S. *pumila* (K.).—Minute, elliptic-lanceolate, with acute apices, and short, marginal, punctated, transverse striæ; stauros reaching the margin. KB. p. 106, pl. 30. f. 43. Marine. Christiania. Front view linear, with rounded angles and truncate ends. 1-1440″ to 1-1080″.

S. *Achnanthes* (E., K.). — Lanceolate, with obtuse apices; striæ distinct, oblique; stauros linear, reaching the margin. KB. p. 106, t. 29. f. 22. = *Stauroptera Achnanthes*, EA. p. 135, pl. 3. 3. f. 7; EM. pl. 17. 1. f. 10. Australia, America, Falaise.

S. *truncata* (Rab.).—Minute, oblong-lanceolate, with very obtuse apices; stauros linear; striæ distinct, oblique, 14 or 15 in 1-1200".=*Stauroptera truncata*, Rab D. p. 49, pl. 9. f. 12. Bosnia.

S. *acrocephala* (Rab.).—Broadly lanceolate; turgid at the middle, rapidly tapering to the acute apices; stauros dilated outwards, reaching the margin; striæ punctate, parallel. Rab D. p. 48, pl. 9. f. 19. Saxony.

S. *acuta* (S.).—Elongated slender-lanceolate or rhomboid, tapering to the subacute apices; stauros conspicuously dilated outwards, reaching the margin; striæ oblique, 30 in ·001". SD. i. p. 59, pl. 19. f. 187. Britain. (VII. 76.)

S. *pulchella* (S.).—Lanceolate, or linear-lanceolate; stauros conspicuously dilated outwards, reaching the margin; striæ oblique, very distinct, punctate, 30 in ·001". SD. i. p. 61, pl. 19. f. 194. Marine. Britain. (VII. 77.). Front view broad, linear-oblong, with rounded angles and constricted centre.

S. *aspera* (E., K.).—Turgid, lanceolate or linear-lanceolate, with subacute apices; striæ oblique, punctate-asperate; stauros abbreviated, dilated outwards. KB. p. 106.=*Stauroptera aspera*, EA. p. 134, pl. 1. 1. f. 12; BC. vii. pl. 1. f. 18. America, Europe. Front view linear, with truncate ends.

2† Valves oval or oblong.

S. *Fenestra* (E.).—Small, elliptic-oblong, with parallel marginal lines, and obtuse, cuneate apices. EA. pl. 2. 1. f. 20. America, Japan.

S. *Peckii* (Rab.).—Small, oval, with rounded ends; costæ stout, 11 or 12 in 1-1200"; stauros linear, reaching the margin. = *Stauroptera Peckii*, Rab D. p. 49, pl. 9. f. 13. Lusatia.

S. *polygramma* (E.).—Elliptic-oblong, with rounded ends and longitudinal dotted lines; stauros abbreviated. EA. p. 135, pl. 2. 6. f. 30. Cuba.

S. *semicruciata* (E.).—Very large, resembling *Navicula viridis*, but having the crucial umbilicus of Stauroneis.=*Stauroptera semicruciata*. EB. 1843, p. 45. Asia.

3† Valves linear.

S. *dendrobates* (E.).—Narrow-linear, with obtuse ends, and a densely and obliquely striated border; front view oblong-quadrate. = *Stauroptera dendrobates*, E. Under moss on trees. America. 1-490".

S. *Roraimæ* = *Stauroptera Roraimæ*, EM. pl. 34. 5 A. f. 9. Linear, with cuneate ends, a transverse median line, and parallel striæ.

S. *oblonga* (Bail.).—Linear, with acute, cuneate ends, and oblique punctato-asperate striæ; stauros abbreviated, dilated outwards.=*Stauroptera oblonga*, BC. vii. p. 10, pl. 1. f. 17. America. The size and markings of *Stauroptera aspera*, E., but having its valves oblong, with parallel sides, and acute angular ends, Bailey.

S. *Isostauron* (E., K.).—Elongated, linear, with broadly rounded, slightly attenuated ends; stauros linear, reaching the margin; striæ parallel. KB. p. 106. =*Stauroptera Isostauron*, EA. p. 135; EM. pl. 16. 1. f. 7. Labrador, Sweden, Finland. (XII. 73.)

S. *Liostauron* (E.).—Styliform, linear-oblong, with scarcely attenuated, rounded apices; stauros linear. EA. p. 135; EM. pl. 5. 1. f. 16. Iceland.

Doubtful Species.

S.? *explicata* (Perty).—Small, not striated, with rounded ends, and much inflated centre (cruciform); enlargements acute. Perty Inf. p. 205, pl. 17. f. 10. Alps. About the size of *S. ventricosum*, K., but still more inflated at the middle, and the inflations pointed, not rounded, Perty. The figure has no median line or other markings, and resembles a Biblarium rather than a Stauroneis.

S. *mesogongyla* (E.).—Lateral view linear, with rounded ends and gibbous centre; transverse striæ parallel, interrupted by a transverse central band. Probably a Navicula, since the figure shows a small, definite central nodule. EM. pl. 6. 1. f. 7. Guiana. Fossil, San Fiore.

S. *gibba* (E., K.).—Form of *Navicula gibba*, but furnished with an imperfect transverse fascia. KB. p. 107, pl. 29. f. 24. = *Stauroptera? gibba*, EA. p. 135, pl. 1. 2. f. 3. America, Africa. The figure represents a Navicula with the striæ shorter opposite the dilated umbilical space.

S. *paucicostata* (Rab.).—Small, linear, with inflated centre, and dilated, rounded apices; costæ distant, 4 or 5 in 1-1200", much inclined. = *Stauroptera paucicostata*, Rab D. p. 49, pl. 9. f. 15. Europe. The figure shows a rhomboid umbilical space resembling the dilated nodule seen in many Naviculæ, but not a true stauros.

S. *maculata* (Bail.).—Oval, with

slightly produced, mammiform apices; surface punctato-striate, with a large smooth central space. BMO. p. 40, pl. 2. f. 32. Florida. Resembles *S. punctata*, K., but is larger, and has the ends not so much produced. The figure shows a dilated umbilical space rather than a true stauros.

S. *scalaris* (E., K.).—Small, linear-oblong, with rounded ends; costæ stout, parallel, 12 in 1-1200″, not reaching the median line. KB. p. 106. = *Stauroptera scalaris*, EA. pl. 4. 2. f. 3. Labrador. (XII. 10, 14, 30.) Scarcely belonging to this genus, since Ehrenberg's figures show a definite central nodule. It differs from *Navicula borealis* by its coarser costæ and their interruption opposite the median nodule.

S. *amphioxys* = *Stauroptera amphioxys*, EM. pl. 6. 1. f. 14. Fossil. Santa Fiore. Ehrenberg's figure represents an elongated, narrow-lanceolate Navicula, with acute apices, and a minute central nodule which is not dilated into a stauros; striæ radiant.

S. *peregrina* = *Stauroptera peregrina*, EM. pl. 6. 1. f. 15. Fossil. Santa Fiore. Ehrenberg's figure represents a small, lanceolate Navicula, with a minute central nodule, but no stauros; striæ radiant.

S.? *ovalis* (Greg.).—Small, smooth, oval; stauros broad, indistinct, reaching the margin. MJ. iv. p. 11, pl. 1. f. 36. Britain. Perhaps a Cocconeis.

Species from Ehrenberg known to us only by name.

S. pusilla, *S. sphærophoron*, *S. Indica*, *S. Placentula*, *S. Hologramma*, *S. gibbosa*, *S. Æthiopica*, *S. Amphisbæna*, *S. Capensis*, *S. Galapagica*, *S. decurrens*, *S. brevirostris*, *Stauroptera nobilis*, *Stauroptera leptocephala*, *Stauroptera Distauridium*, *Stauroptera Braziliensis*, *Stauroptera Tabellaria*, *S. asperula*, *Stauroptera Siamensis*, *Stauroptera trinodis*.

Genus STAUROGRAMMA (Rab.).—Like Stauroneis, but with decussating striæ, and prominent knots at the intersections, Rab.

STAUROGRAMMA *Persicum* (Rab.).—Oblong-lanceolate, with truncate apices; stauros linear, reaching the margin; median line dilated towards the ends. Rab D. p. 50. = *Stauroptera decussata*, Rab D. pl. 9. f. 14. Persia. (VIII. 36.)

Genus PROROSTAUROS (E.).—Frustules simple, free; with the characters of Stauroneis, except that its terminal puncta in the front view are approximate and not lateral. We doubt whether this genus can be separated from Stauroneis; for, if we understand Ehrenberg's definition, the apparent position of the terminal puncta depends upon the greater convexity of the lateral valves, which therefore appear, in the front view, like a border on each side of the connecting zone, and the puncta are within the angles. The species are unknown to us. EB. 1843, p. 136.

PROROSTAUROS *splendens* (E.).—River Senegal.

P.? *subulatus*? (E.).—Senegal, Cape of Good Hope. At first sight it reminds one of *Gomphonema gracile*, E.

Genus PLEUROSIPHONIA (E.).—The characters of this genus are unknown to us; but, from Ehrenberg's figure of *P. affinis*, we think it is probably identical with Mastogloia.

PLEUROSIPHONIA *affinis* (E.).—Oblong-lanceolate, with capitate ends, median line and nodules, and a marginal band of transverse striæ. EB. 1856, p. 32. = *Fragilaria Navicula*, E. 1841; EM. 33. 1. f. 14. Arabia, Africa, Peru.

Species known only by name.

P. Amphisbæna (E.), Arabia, Africa, Peru, Mexico; *P. fulva* (E.), Arabia, Africa; *P. Phœnicenteron* (E.), Arabia, Africa; *P. Libyca* (E.), Africa; *P. obtusa* (E.), Africa; *P. gracilis* (E.) Africa.

Genus PLEUROSIGMA (Smith) (Gyrosigma, *Hassall*, *Rabenhorst*, &c.).—Frustules simple, free, elongated; front view linear or lanceolate, narrower than the lateral view; valves depressed or slightly convex, sigmoid (rarely straight), with a sigmoid median line, central and terminal nodules, and fine decussating striæ, which are resolvable into dots. Pleurosigma is distinguished from Donkinia and Amphiprora by the elongated-narrow front view and more depressed valves. The median line, also, is sigmoid, whilst in those genera it is usually straight, or appears sigmoid merely from the twisting of the frustule. This genus was first separated by Dr. Hassall from Navicula, under the name of Gyrosigma. Hassall, however, like Ehrenberg, erroneously considered it identical with the Sigmatella of Kützing, whereas they belong to very distinct families; and even their sigmoid forms belong to different surfaces, Sigmatella having it in the front, and this genus in the lateral view. Gyrosigma has been adopted by Rabenhorst and others; nor do we think the name so objectionable as to render its rejection necessary. If, then, we admit Professor Smith's name, we do so for the reasons given by Brébisson:—"Gyrosigma (Hass.).—Peutêtre ce dernier nom de genre n'était-il pas bien convenable selon les lois de la nomenclature; dans tous les cas, il est certain que, malgré son droit de priorité, il est à peu près généralement abandonné. D'ailleurs, on est d'autant moins disposé à reprocher ce changement de nom à M. W. Smith, que le soin tout monographique qu'il a apporté à l'étude des nombreuses espèces de Pleurosigma qu'il a découvertes, en fait un genre tout à lui" (Bréb DC. p. 17). Ehrenberg does not admit Pleurosigma, because it "does not differ in its physiological characters from Navicula" (EB. 1854, p. 236).

* *Frustules rostrate.*

† Beaks filiform.

PLEUROSIGMA *Fasciola* (E., S.).—Turgid-lanceolate, with long linear beaks abruptly curved in contrary directions; striæ 64 in ·001″, indistinct. SD. i. p. 67, pl. 21. f. 211. = *Ceratoneis Fasciola*, E. Marine. Europe. (XII. 60, 61.) Colour of dry valve pale-pink. 1-430″. Mr. Sollitt states this Diatom near Hull is very small, the markings 90 in ·001″, while those from Boston in Lincolnshire are large, with only 50 striæ in ·001″.

P. *macrum* (S.).—Elongated slender-lanceolate, with very long filiform beaks curved in contrary directions; transverse striæ 85 in ·001″, very indistinct. SD. i. p. 67, pl. 31. f. 276. Brackish water. England.

P. *prolongatum* (S.). — Narrow-lanceolate, gradually tapering into slender beaks curved in contrary directions; transverse striæ 65 in ·001″, indistinct. SD. i. p. 67, pl. 21. f. 212. Marine. England.

P. *arcuatum* (Donkin). — Turgid-lanceolate, straight, with long, very slender, strongly arcuate beaks curved in contrary directions; striæ obscure; median line straight, central. TM. vi. p. 25, pl. 3. f. 10. Marine. England. Closely allied to *P. macrum*, but distinguished from it by the long, strongly arcuate beaks. Dry valves very pale-brown. (Donkin.)

2 † Beaks short, stout.

P. *distortum* (S.).—Stout, turgid-lanceolate, produced into short, broad, obtuse, subrostrate extremities, which are abruptly bent in contrary directions; transverse striæ obscure, 75 in ·001″; median line central. SD. i. p. 67, pl. 20. f. 210. Marine. England. Small; colour pale pink. 1-320″.

P. *Æstuarii* (Bréb., S.). — Broadly lanceolate, rapidly tapering into subrostrate, obtuse ends; median line diagonal, submarginal near the ends; striæ oblique, 54 in ·001″; colour pale purple. SD. i. p. 65, pl. 31. f. 275. = *Navicula Æstuarii*, KA. p. 890; *Gyrosigma Æstuarii*, Bréb. Marine. Europe. Rather small; 1-290″. Habit of *P. Thuringicum*, but smaller, paler, and without the marginal notch, Kütz.

P. *littorale* (S.). — Turgid-lanceolate, rapidly attenuated into the curved, subrostrate, somewhat acute ends; longitudinal striæ conspicuous, 24 in ·001″, transverse 50 in ·001″; colour purplish. SD. i. p. 67, pl. 22. f. 214. Marine. Europe. 1-200″; median line subcentral.

2 * *Valves gibbous at the middle.*

P. *Sinensis* (E.). — Large, elongated, broadly linear, flexuose, sigmoid, with gibbous centre and broadly rounded, somewhat incrassated ends, which are curved in contrary directions. = *Navicula*

Sinensis, EB. 1847, p. 484; EM. pl. 34. 7. f. 11. China. 1-80″.

P. *reversum* (Greg.). — Elongated narrow-linear, with inflated or lanceolate centre, and dilated ends which are turned in contrary directions; median line sigmoid, subcentral except near the ends; striæ extremely fine. GDC. p. 58, pl. 6. f. 105. Marine. Scotland. This form may be identical with *P. Sinensis*; but the valves are narrower and with less-rounded apices than in Ehrenberg's figure of that species.

3 * *Valves linear.*

P. *Balticum* (E., S.).—Large, broadly linear, straight, except towards the attenuated obtuse ends, which are curved in contrary directions; longitudinal and transverse striæ, 38 in ·001″; colour dark brown. SD. i. p. 66, pl. 22, f. 207. =*Navicula Baltica*, E Inf. pl. 13. f. 10; *Gyrosigma Balticum*, Rab D. p. 47, pl. 5. f. 6; *P. makron*, Johnston, MJ. viii. Marine or brackish waters. Common. (VIII. 33; IX. 144.) 1-70″. Median line flexuose, subcentral.

P. *obscurum* (S.).—Small, linear, with attenuated, rather obtuse ends; median line very flexuose, not central; striæ oblique, 75 in ·001″. SD. i. p. 65, pl. 20. f. 206. Marine or brackish waters. Britain. Var. β smaller. 1-193″; colour pale pink; median line marginal near the ends.

P. *simum* (E.). — Small, linear, with the ends obliquely rounded on opposite sides; median line sigmoid, nearly central. = *Navicula sima*, EB. 1845, p. 363; EM. pl. 34. 7. f. 9. India. 1-430″.

P. *Scalpellum* (K.). — Small, linear, slightly sigmoid, gradually attenuated into the obtuse apices; median line subcentral. = *Navicula Scalpellum*, KA. p. 85; KB. pl. 30. f. 13; *Gyrosigma Scalpellum*, Rab D. p. 47, pl. 5. f. 10. Trinidad, Persia.

P. *Sciotoensis* (Sullivant). — Linear, moderately sigmoid, gradually attenuated into the rather obtuse ends; striæ transverse and longitudinal, 40 in ·001″. Silliman's J. xxvii. p. 251. Fresh water. United States. ·001″. "Not unlike *P. Spencerii*, for which it has passed as a variety; but it is a larger species, with sides more parallel and ends less acute. Its striation at once distinguishes it" (Sull.).

4 * *Valves lanceolate or linear-lanceolate.*

† Valves linear-lanceolate.

P. *Wansbeckii* (Donkin).—Linear-lanceolate, with tapering, subacute, slightly sigmoid ends; median lines sigmoid, not central; longitudinal and transverse striæ, about 50 in ·001″. Donkin, TM. vi. p. 24, pl. 3. f. 7. = *P. Balticum*, β, SD. Marine. England. Pale straw-coloured. ·0045″ to ·005″. Much smaller than *P. Balticum*, and with more numerous striæ.

P. *lamprocampum* (E.). — Slender, narrowly linear-lanceolate, tapering to the rather obtuse apices; sigmoid, with fine transverse striæ; median line central; front view linear. = *Navicula lamprocampa*, EB. 1840, p. 20; KB. p. 102, pl. 4. f. 5; *Gyrosigma lamprocampum*, Rab D. p. 47, pl. 5. f. 9. Marine. Europe, 1-144″.

P. *curvulum* (E.).—Linear-lanceolate, with rather obtuse apices, sigmoid. = *Navicula curvula*, E Inf. pl. 13. f. 14; *Gyrosigma curvulum*, Rab D. p. 47, pl. 5. f. 8. Europe, America.

P. *speciosum* (S.).—Linear-lanceolate, flexed chiefly at the somewhat abrupt, obtuse ends; median line submarginal near the ends; striæ oblique, 44 in ·001″; SD. i. p. 63, pl. 20. f. 197. England. Pale straw-colour. 1-85″. It is shorter, less tapering, and has more rounded apices than *P. formosum*; the median line also is not diagonal at the centre.

P. *formosum* (S.).—Large, elongated, linear-lanceolate, much flexed, gradually tapering to the obtuse apices; median line diagonal; striæ oblique, 36 in ·001″. SD. i. p. 63, pl. 20. f. 195. Marine. England. (VIII. 32.) Colour chestnut-brown. 1-66″. Well distinguished by the position of its median line, which, owing to a twist in the valves, appears to coincide with the edges for a considerable distance at either end, and then crosses in a diagonal direction.

P. *Longinum* (Bri.). — Lanceolate, flexure moderate, extremities greatly elongated, acute; median line central; striæ transverse, 36 in ·001″. ·020″ to ·025″. Colour pale straw. TM. vii. p. 180, pl. 9. f. 7. Arctic regions.

P *sinuosum* (E.). — Small, striated, linear-lanceolate; striæ 15 in 1-1200″. 1-480″. = *Navicula sinuosa*, EB. 1840, p. 21. Marine. Europe. Has the figure of *P. simum*, but is more slender.

P. *subtile* (Bréb.).—Very slender, pellucid and delicate; slightly sigmoid, very narrow linear-lanceolate, subuliform with rather obtuse apices. = *Navicula subtilis*, KA. p. 87. Marine. France. 1-160″ to 1-120″.

P. *tenuissimum* (S.). — Very narrow linear-lanceolate, gradually tapering to a fine point; transverse striæ 48 in ·001″; median line central. SD. i. p. 67, pl. 22. f. 213. Brackish water. Essex.

P. *Apulum* (Rab.).—Slender-lanceolate, much curved, with obtuse ends, transversely striated; front view broadly linear. Rab D. p. 47, pl. 5. f. 7. Italy. In the figures the valves are linear, very but not symmetrically sigmoid, with tapering ends and central median line.

2 † Valves lanceolate, with oblique striæ.

P. *delicatulum* (S.). — Slender-lanceolate, gradually tapering to the acute apices; flexure moderate; median line central; striæ oblique, 64 in ·001″. SD. i. p. 64, pl. 21. f. 202. Brackish water. Britain. Length 1-112″; breadth 1-1500″. Colour pale pink.

P. *inflatum* (Shadbolt). — Small, broadly-lanceolate, with acute apices; median line central, much flexed, as well as the valve; striæ oblique. TM. ii. p. 16, pl. 1. f. 9. Marine. Natal.

P. *decorum* (S.). — Large, elongated, rhomboid-lanceolate, uniformly flexed, gradually tapering to the subacute apices; striæ oblique, 36 in ·001″; median line diagonal, marginal near the ends. SD. i. p. 63, pl. 21. f. 196. Brackish water. England. Colour pale chestnut.

P. *angulatum* (Quekett, S.). — Large, broad, sigmoid, rhomboid-lanceolate, rapidly tapering to the subacute apices; median line somewhat diagonal; striæ oblique, 52 in ·001″. SD. i. p. 65, pl. 21. f. 205. = *Navicula angulata*, Quekett, Microsc. p. 438, pl. 8. f. 4 to 7. Marine. Britain. Colour pale chestnut; flexure moderate.

P. *quadratum* (S.). — Large, very broad rhomboid, rapidly tapering to the subacute apices, which are slightly flexed; striæ oblique, 45 in ·001″; median line central. SD. i. p. 65, pl. 20. f. 204. = *P. angulatum*, ANH. 2nd series, ix. p. 7. Marine. Europe. Colour chestnut; length 1-110″; breadth 1-428″. Easily recognized by its very broad angular form.

P. *lanceolatum* (Donkin). — Straight, broadly lanceolate, acute; median line straight or gently sigmoid, with the terminal nodules turned in contrary directions; striæ very fine, oblique, about 70 in ·001″. TM. vi. p. 22, pl. 3. f. 4. = *P. transversale*, *β*, Mr. Roper. Marine. England. Straw-coloured; ·0055″ to ·006″; front view narrow linear-lanceolate. The extremely fine striæ require the most careful manipulation with very oblique light, to render them visible with a superior 1-5th objective.

P. *naviculaceum* (Bréb.). — Rather small, lanceolate, straight, gradually tapering to the obtuse apices, which are slightly turned in contrary directions; median line sigmoid, not central; striæ very fine, oblique. B. Diat. of Cherbourg, 1854, p. 17, f. 7. = *Gyrosigma transversale*, Microg. Dict. pl. 11. f. 37, 38; *P. transversale*, SD. ii. p. 96. Marine. Common, especially in deep waters. This species, viewed laterally, greatly resembles a Navicula in its lanceolate straight form. Its apices are only slightly inclined to opposite sides. The median line, however, is sigmoid, and the striæ are oblique and decussating.

P. *marinum* (Donkin).— Broadly lanceolate, straight, slightly sigmoid near the obtuse ends; median line sigmoid on each side of the central nodule; striæ oblique. TM. vi. p. 22, pl. 3. f. 3. Marine. Northumberland. Straw-coloured; striæ about 45 to 50 in ·001″. ·0055″ to ·006″. The well-marked sigmoid flexure of the median line on both sides of the central nodule distinguishes this species, and renders it easy of recognition.

P. *Nubecula* (S.).—Small, lanceolate, nearly straight, with obtuse apices, central median line, and 55 oblique striæ in ·001″; colour very pale. SD. i. p. 64, pl. 21. f. 201. Marine. England.

P. *intermedium* (S.).—Elongated, pale straw-colour, slender lanceolate, nearly straight, tapering to the subacute apices; median line subcentral; striæ oblique, 55 in ·001″. SD. i. p. 64, pl. 21. f. 200. Marine. England.

P. *rigidum* (S.). — Large, stout, pale straw-colour, lanceolate, nearly straight, with rounded apices; median line central; striæ oblique, 48 in ·001″. SD. i. p. 64, pl. 20. f. 198. Marine. England.

P. *validum* (Sh.).—Large; lanceolate, nearly straight, with very obtuse apices, oblique striæ, and slightly flexed median line. MT. ii. p. 16, pl. 1. f. 8. Marine. Natal.

P. *elongatum* (S.). — Large, much elongated, lanceolate, gradually tapering to the acute apices, nearly straight, except at the ends, which are slightly curved; striæ oblique, 48 in ·001″; median line nearly straight. SD. i. p. 64, pl. 20. f. 199. Marine. England. Clear straw-colour. Length 1-75″; breadth 1-920″.

P. *strigosum* (S.). — Large, elongated, broadly lanceolate, gradually attenuated to the obtuse apices; flexure slight; median line not central near the ends; striæ oblique, 44 in ·001″. SD. i. p. 64, pl. 21. f. 203. Marine. Britain. 1-90″; colour pale straw; front view narrow linear-lanceolate, with obtuse apices.

3 † Valves lanceolate, with longitudinal and transverse striæ.

P. *obtusatum* (Sullivant). — Oblong-lanceolate, slightly sigmoid, with obtuse apices; ·0025″; striæ transverse and longitudinal, 56 in ·001″. Silliman's J. xxvii. p. 251. Fresh water. United States. A very small species, remarkable for the obtuse ends. It may be a Colletonema, but we have not observed it in gelatinous envelopes.

P. *Spenceri* (Quekett, S.). — Small, lanceolate, moderately flexed, gradually tapering to the obtuse apices; median line central; striæ very fine, transverse 50 in ·001″, longitudinal 55 in ·001″. SD. i. p. 68, pl. 22. f. 218.=*Navicula Spenceri*, Quekett. Fresh water. America, Europe. Colour pale brown. 1-270″.

P. *Parkeri* (Harrison). — Lanceolate, considerably flexed, apices produced, median line central; striæ transverse, 55 to 60 in ·001″; longitudinal striæ faint; colour pale yellow. Lincolnshire. MJ. viii. p. 105.

P. *Wormleyii* (Sullivant). — Lanceolate, conspicuously sigmoid, suddenly attenuated into acute apices; ·003″; striæ, longitudinal and transverse, 52 in ·001″. Silliman's J. xxvii. p. 251. Fresh water. United States. Resembles *P. Spenceri*, but is a smaller species, more evidently sigmoid, and with rather abruptly attenuated ends; its striæ are more difficult to resolve, and the texture of its valves is thinner.

P. *lacustre* (S.).—Lanceolate, considerably flexed, gradually tapering into the obtuse apices; longitudinal and transverse striæ, 48 in ·001″; median line subcentral. SD. i. p. 68, pl. 21. f. 217. Fresh water. England. 1-144″.

P. *Thuringicum* (K.).—Lanceolate, sigmoid, gradually attenuated to the subacute apices, obsoletely notched at the middle of each margin; median line central; striæ wanting or indistinct.= *Navicula Thuringica*, KB. p. 102, pl. 4. f. 27; *Gyrosigma Thuringicum*, Rab D. p. 47, pl. 5. f. 4. Thuringia. Front view narrow-linear; 1-264″ to 1-168″.

P. *Agellus* (E.). — Large, lanceolate, flexed, gradually tapering to the obtuse apices, marked longitudinally with very fine lines, and thus appearing furrowed; median line central.=*Navicula Agellus*, EB. 1840, p. 18; EM. pl. 15 A. f. 31; *Gyrosigma Agellus*, Rab D. p. 47. Fresh water. Germany, Lough Mourne deposit, Siberia. Front view nearly linear, with subacute apices; 180″. Is more slender and longer than *P. Hippocampus*, E.

P. *attenuatum* (K., S.).—Large, elongated, flexed, lanceolate, gradually attenuated into the obtuse apices; longitudinal striæ 30, and transverse 40 in ·001″; median line central. SD. i. p. 68, pl. 22. f. 216.=*Navicula attenuata*, KB. p. 102, pl. 4. f. 28; *Gyrosigma attenuatum*, Rab D. p. 47. Fresh water. Europe. 1-120″. Colour purplish brown; front view narrow-lanceolate, with truncate ends.

P. *cuspidatum* (Rab.). — Slender-lanceolate, very much flexed, with long, tapering, obtuse ends; median line central. = *Gyrosigma cuspidatum*, Rab D. p. 47, pl. 5. f. 5, 6. Fresh water. Europe, America. It is always mixed with *P. acuminatum*.

P. *acuminatum* (K., S.).—Lanceolate, tapering into the obtuse apices; flexure considerable; median line central; longitudinal striæ 40 in ·001″, transverse 52 in ·001″. SD. i. p. 66, pl. 21. f. 209. = *Navicula acuminata*, KB. p. 102, pl. 4. f. 26; *Navicula Sigma*, EB. 1843, p. 209; *Gyrosigma Hassallii*, Rab D. p. 47. Marine. Europe, Asia, Africa, America. (IX. 146.) Front view narrow-linear, with obtuse apices; 1-162″; colour pale brown.

P. *Hippocampus* (E., S.). — Large, elongated, broadly lanceolate, obtuse; flexure considerable; colour pale brown; striæ as in *P. attenuatum*; median line central. SD. i. p. 68, pl. 22. f. 215.= *Navicula Hippocampus*, E Inf. pl. 13. f. 9; *Gyrosigma Hippocampus*, HBA. pl. 102. f. 11; Rab D. p. 47. Marine. Europe. (IX. 145.) 1-166″; front view linear, truncate.

P. *Strigilis* (S.). — Large, much elongated, lanceolate, uniformly tapering to the subacute apices, flexed; median line central; striæ, transverse and longitudinal, 36 to 40 in ·001″. SD. i. p. 66, pl. 22. f. 208. Brackish water. England. Length 1-80″; breadth 1-830″; colour pale brown. Notable for its graceful form and distinct striæ.

P. *Scalprum* (Gaillon). — Small, sigmoid, gradually attenuated into the rather obtuse apices, longitudinally striated.=*Cymbella Scalprum*, AD. p. 11; *Navicula Scalprum*, E. Inf.; KB. pl. 4. f. 25. Marine. Europe, Asia, America. Length 1-430″ to 1-290″.

P. *Normanii* (n. sp.). — Broadly lanceolate, slightly flexed, with rather obtuse ends, and a slight, transverse central depression; median line stout, nearly central; striæ oblique, 40 in ·001″. = *P. lanceolatum*, Norman, *MS.* Marine. Europe. Found in nearly every gathering from deep water, and in stomachs of Ascidians, Noctilucæ, Pectens, &c. Colour tawny brown; ·0048″ to ·0110″; median line scarcely flexed, except near the ends. The description is by George Norman, Esq.

P. *acutum* (Norman, *MS.*) — Large, broadly lanceolate, elongated, moderately flexed, gradually tapering to the very acute apices; median line delicate, much flexed, not central; striæ oblique, 50 in ·001″ Marine. Stomachs of Ascidians, &c. Europe. Very pale straw-colour or nearly hyaline; ·011″; median line flexed throughout.

Genus TOXONIDEA (Donkin). — Frustules simple, free; lateral valves elongated convex, with the sides not symmetrical; median line arcuate, with central and terminal nodules, its ends curved towards the same margin; striæ oblique. Marine. Toxonidea is closely allied to Pleurosigma; indeed the forms placed here are regarded by Professor Arnott as distorted species of that genus. The absence, however, of a sigmoid flexure, both in the valves and median line, is so different from what we find in Pleurosigma, that we think it advisable to admit Toxonidea until Dr. Donkin's views are disproved by more perfect observation.

Toxonidea *Gregoriana* (Donkin).— Large, lanceolate, with the obtuse ends curved upwards; median line concurrent with the lower margin near the ends; striæ fine, oblique, about 50 in ·001″. TM. vi. p. 19, pl. 3. f. 1. Britain. Straw-coloured; ·008″ to ·009″; median line curved upwards near the end, and "resembling the figure of an unbent Scythian bow;" *dorsum* rather more convex than the *venter*.

T. *insignis* (Donkin). — Arcuate or semi-lunate, with produced, subacute ends; median line not central, strongly arcuate; striæ very fine, about 75 or 80 in ·001″. TM. vi. p. 21, pl. 3. f. 2. ·0048″ to ·006″; "valves resembling a straw-coloured strung bow or a cocked hat," with very convex or gibbous dorsum and straight venter. Professor Arnott regards this species as a distorted state of *Pleurosigma Æstuarii*. Britain.

T. *undulata* (Norman, *MS.*).—Arcuate, with three slight dorsal undulations, obtuse somewhat recurved apices, and concave venter gibbous at its centre; striæ oblique, 50 in ·001″. From Ascidians. North Sea. Very pale straw-colour, with pinkish reflections; ·0055″; longitudinal suture concurrent with the ventral margin except at the inflated centre. (VIII. 46.)

Genus DONKINIA (n. g.). — Frustules simple, free; front view panduriform, as broad as the lateral view; valves convex, keeled, with nodules and decussating striæ as in Pleurosigma. Marine. We have constituted this genus for the reception of some Diatoms possessing characters intermediate between Pleurosigma and Amphiprora, and have much pleasure in dedicating it to Dr. Donkin, who, amongst his many interesting discoveries, first directed attention to several of the species placed in it. Dr. Donkin referred the species to Pleurosigma on account of the similarity of striation; but they differ from that genus in the broad, constricted front view; and from these characters, together with their very convex, keeled valves, we were induced to regard them as more nearly allied to Amphiprora. Indeed there is little essential difference between keel, crest, and wing, these being, in our opinion, merely different stages of development. This opinion was also adopted by Professor Arnott, whose critical knowledge of genera commands the highest deference. The species placed in Donkinia differ from Amphiprora, not only in their decussating striæ (a character sometimes difficult to verify, and of rather doubtful generic value), but also, according to Dr. Donkin, in the absence of lateral wings to the valves.

Donkinia *cristata* (E.).—Narrow-lanceolate, gradually subulate at each end; central nodule transversely oblong; median line sigmoid, crested. = *Navicula* *cristata*, EB. 1854, p. 240; EM. pl. 35 BB. 4. f. 13. Atlantic.

D. *inversa* (E.).—Short, narrow, sigmoid, with subacute apices; front view very broad, quadrangular, constricted at the middle, with broadly truncate ends and marginal glands. = *Navicula inversa*, EB. 1840, p. 18. Europe. 1-576″. "It is allied to *Amphiprora alata*, but wants the winged portions" (E.).

D. *carinata* (Donkin).—Straight, linear-lanceolate, acute, very convex; colour dull purple; median line strongly sigmoid, marginal near each end; striæ oblique, fine, about 55 to 60 in ·001″. = *Pleurosigma carinatum*, Donkin, *l. c.* p. 23, pl. 3. f. 5. England. ·0046″; valve twisted; median line diagonal at the centre, marginal near the ends. (VIII. 49.)

D. *compacta* (Grev.).—Straight, very convex, linear, obtuse, sigmoid from having the ends sloped in contrary directions; median line much flexed, diagonal at the centre, marginal near the ends; striæ very fine, 53 to 60 in ·001″. = *Pleurosigma compactum*, MJ. v. p. 12, pl. 3. f. 9; *Pleurosigma rectum*, Donkin, TM. vi. p. 23, pl. 3. f. 6; *Amphiprora Ralfsii*, Arnott, MJ. vi. p. 91. Britain. ·0045″ to ·005″. According to Dr. Donkin, the striæ are longitudinal and transverse; colour very pale.

D. *minuta* (Donkin).—Short, very convex, linear-oblong, subacute, sigmoid from the sloping of one margin near each end in contrary directions; median line much flexed; striæ very fine, transverse ones distinct, about 55 in ·001″, longitudinal ones obscure. = *Pleurosigma minutum*, Donkin, *l. c.* p. 24, pl. 3. f. 8. England. ·0025″; colour, very pale brown. *D. minuta* seems to differ from *D. compacta*, to which Professor Arnott would unite it, chiefly in its smaller size.

D. *angusta* (Donkin).—Very convex, linear, with acute, slightly apiculated apices; median line strongly sigmoid, marginal, except a central diagonal portion; striæ obscure, longitudinal. = *Pleurosigma angustum*, Donkin, *l. c.* p. 24, pl. 3. f. 9. England. ·005″ to ·0055″; colour dull purple. Another form closely allied to D. *compacta*.

D. *reticulata* (Norman, *MS.*).—Linear-lanceolate, with rather obtuse apices; median line strongly diagonal at the centre, then marginal and slightly projecting; striæ oblique, distinct, 22 in ·001″. Stomach of Ascidians, Shark's Bay, Australia. Collected by Dr. Macdonald. Colour purplish brown; front view oblong, with truncate ends and constricted middle. For the description of this species we are indebted to George Norman, Esq.

Genus AMPHIPRORA (Ehr.) (Entomoneis, *Ehr.*).—Frustules free, simple, in front view constricted at the middle; valves convex, with a longitudinal wing, and central and terminal nodules; striæ, when present, transverse. Marine. Amphiprora is distinguished by its lateral wings, which are constricted at the middle, so that the frustule in front view, when not twisted (which, however, frequently occurs), is more or less panduriform, with truncate or broadly-rounded ends. The late Professor Smith stated that the peculiar frustules of this genus could not be confounded with any others, save those of a few species of Nitzschia. From the recent discoveries of Dr. Donkin, Amphiprora is found far more closely allied to Pleurosigma and Donkinia. From these genera it differs by its alate valves, and by having transverse striæ only. According, however, to the late Professor Gregory and Dr. Donkin, the valves of Amphiprora are furnished, in addition to the median crest, with lateral ones also, similar to those of Surirella; and certainly the frustules in the front view most frequently exhibit a longitudinal line on each side between the margin and the central portion—an appearance not unlikely to depend on such a formation, particularly in *A. ornata* and *A. paludosa*, in which these lines are undulated. An end view is required to ascertain whether this be really the case, since the same appearance would result from a depression along the sides of the median crest, and even the undulations may be produced by transverse ridges.

AMPHIPRORA *alata* (E., K.).—Very hyaline, generally twisted; front view broadly winged, strongly constricted; wing continued round the ends; lateral view with apiculate ends and a double line of puncta accompanying the keel; striæ 42 in

·001″. KB. p. 107; SD. i. p. 44, pl. 15. f. 124.=*Navicula* and *Entomoneis alata*, EB. 1845, p. 154. Common, especially in salt-water marshes. (xiii. 5 to 7.) 1-570″ to 1-430″; central portion with longitudinal lines.

A. *Kützingii* (Bréb.).—Very hyaline; front view slightly constricted, longitudinally lined, with rounded apices. KA. p. 93. France.

A. *constricta* (E.). — Very hyaline; front view oblong, sinuato-constricted, with rounded ends; lateral view narrow, with straight median line, and transverse stauros-like band. EA. p. 122, pl. 2. 6. f. 28; SD. i. p. 44, pl. 15. f. 126. Europe, America. (xii. 1.) Striæ very faint, 68 in ·001″.

A. *duplex* (Donkin).—Broad, panduriform, with truncate ends and rounded angles; lateral view narrow, not striated; keel strongly sigmoid, unaccompanied by puncta. TM. vi. p. 165, pl. 3. f. 13. England. Resembles *A. alata* in the broad, deeply-constricted front view with conspicuous alæ, but differs from it in the absence of striæ and puncta, and in the narrow-linear lateral view.

A. *plicata* (Greg.).—Front view deeply constricted, with broadly rounded ends; each valve with a plate extending from its inner margin to the nodule, furnished like the wings with about 50 fine transverse striæ in ·001″; central portion with faint vertical lines or folds. GDC. p. 33, pl. 4. f. 57. Scotland. Approaches nearest to *A. alata*, but differs from it in the folds of the middle space, and in the presence of lateral plates. Judging from the figure quoted, the longitudinal lines are similar to those present in *A. alata* and other species, and we doubt the distinction of the lateral plates.

A. *pulchra* (Bailey). — Large; front view deeply constricted, with rounded ends, distinctly striated, punctate near the margin. BC. ii. p. 38, pl. 2. f. 16 & 18. Florida. Often twisted; central portion narrow, sigmoid, with a few fine longitudinal lines.

A. *quadrifasciata* (Bailey).—Small; front view moderately constricted, with truncate or slightly rounded ends; valves striated, lanceolate, with produced rostellate apices. BC. ii. p. 38, pl. 2. f. 2–4. United States. When living, the colouring matter forms four yellowish transverse bands; not contorted.

A. *vitrea* (S.).—Straight; front view oblong, with rounded ends and slight constriction; lateral view lanceolate; striæ 52 in ·001″. SD. i. p. 44, pl. 31. f. 270. Britain.

A. *elegans* (S.).—Straight; front view linear-oblong, with broadly rounded ends and very slight notch-like constriction; lateral view lanceolate; striæ 40 in ·001″. SD. ii. p. 90.; GDC. p. 33, pl. 4. f. 58. Britain. "Distinguished from *A. vitrea* by its longer and comparatively more lanceolate and slender frustule, and closer striæ" (S.). Professor Arnott would unite this with *A. vitrea*.

A. *obtusa* (Greg.).—Front view linear-oblong, with slightly sinuated sides and rounded ends; striæ very fine. GDC. p. 34, pl. 4. f. 60. Scotland. Alæ of nearly uniform breadth.

A. *minor* (Greg.).—Front view oblong, with slightly sinuated sides and rounded ends; striæ rather coarse; central smooth portion lanceolate. TM. v. p. 75, pl. 1. f. 38. Scotland.

A. *pusilla* (Greg.). — Front view quadrangular; alæ slightly constricted, the constriction apparently overlapped by the convexity of the valve; lateral view acutely lanceolate; striæ fine, about 60 in ·001″. GDC. p. 33, pl. 4. f. 56. Scotland.

A. *lepidoptera* (Greg.). — Elongated; front view linear, with broadly rounded ends; the notch-like constriction of the alæ apparently overlapped by the convexity of the valve; lateral view lanceolate, apiculate; striæ fine, about 48 in ·001″; GDC. p. 33, pl. 4. f. 59. Scotland. The alæ are carried round the ends, and in the lateral view appear like an apiculus.

A. *maxima* (Greg.).—Front view very broad, panduriform, with rounded ends, the notch-like constriction overlapped by the convexity of the valve; striæ distinct, about 36 in ·001″; lateral view acutely lanceolate. GDC. p. 35, pl. 4. f. 61. Scotland.

A. *complexa* (Greg.). — Front view broadly panduriform, with broadly rounded ends; alæ with marginal puncta; striæ delicate, about 45 in ·001″; central portion oblong, with concentric longitudinal lines. GDC. p. 36, pl. 4. f. 62. Scotland.

A. *paludosa* (S.).—Twisted; front view dilated, broadly winged, deeply constricted, with rounded or truncate ends, and a waved longitudinal line on each side between the margin and central portion; striæ 60 in ·001″ SD. i. p. 44, pl. 31. f. 269. Britain. Fresh or slightly brackish water, according to Smith; marine, according to Professor Arnott.

A. *ornata* (Bailey).—Small; front view deeply constricted, with truncated or rounded ends, and a longitudinal row of undulations on each side. BC. ii. p. 38, pl. 2. f. 15 & 23. America. Often twisted. "The ruffle-like rows of pinnules distinguish this species from all others" (Bailey).

Doubtful Species.

A. *recta* (Greg.). — Front view quadrangular, with rounded angles and very slightly constricted sides; striæ fine but distinct. TM. v. p. 67, pl. 1. f. 40. Scotland. The figure presents no appearance of alæ, but only convex lateral valves, such as are seen in several species of Navicula.

A. *navicularis* (E.). — Oblong, with obtuse ends and radiant transverse striæ; front view quadrangular, with two puncta at each end. EA. p. 122; EM. several figures. Fresh water. America. Apparently a Navicula with the terminal puncta of the front view less marginal than usual.

Genus DIADESMIS (Kütz.).—Frustules navicular, united into a filament; valves with central and terminal nodules. Habit of Fragilaria, but the valves furnished with median line and central nodule. Diadesmis differs from Sphenosira only in having the lateral surfaces with similar ends.

* *Freshwater or Fossil.*

DIADESMIS *confervacea* (K.).—Breadth of articulations twice the length; valves minute, smooth, with acute, acuminate ends. KB. p. 109, pl. 30. f. 8. Trinidad. (XIV. 32, 33.) 1-960''.

D. *lævis* (E., K.). — Smooth; breadth of articulations three to four times the length. KB. p. 109, pl. 29. f. 69. = *Tabellaria lævis*, EA. pl. 1. 2. f. 17. Chili. (XII. 40.)

D. *sculpta* (E., K.). — Articulations with striated margins; valves linear-oblong, with rounded ends and a narrow striated border. KB. p. 109, pl. 29. f. 26. = *Tabellaria sculpta*, EA. pl. 1. 2. f. 6. Chili. Resembles *Navicula borealis*, E.

D. ? *Bacillum* (E., K.).—Articulations striated, linear-oblong, with rounded ends, and a large, oblong, longitudinal median nodule. KB. p. 109. = *Navicula Bacillum*, E. Fossil. Greece.

D. *Navicula* (E.). — Frustules oblong, smooth, four or five times as long as broad, with a smooth median stricture. = *Fragilaria* ? *Navicula*, EA. p. 127, pl. 1. 3. f. 8. Peru. We place this form in Diadesmis because the frustules, in the front view, have a minute punctum at the middle of each lateral margin,— an appearance which usually indicates the presence of central nodules.

D. *Gallica* (S.). — Filaments straight or curved; valves linear-elliptical, with about 45 obscure striæ in ·001''. Sm. ANH. Jan. 1857, p. 11, pl. 11. f. 16. Havre.

D. *peregrina* (S.).—Victoria tank, Glasgow. This species is unknown to us.

2* *Marine.*

D. *Williamsoni* (S., Greg.). — Front view linear, with central and terminal dilatations; valves linear, with attenuated ends and 16 to 18 dotted striæ in ·001. GDC. p. 25, pl. 2. f. 40. = *Himantidium Williamsoni*, SBD. ii. p. 14, pl. 33. f. 287. Marine. Scotland.

Genus STIGMAPHORA (Wallich). — Frustules free, naviculoid; valves lanceolate, loculate; loculi with central and marginal puncta. Marine. Frustules very hyaline, with two minute cells at the middle of each margin in both views; valves with median line.

STIGMAPHORA *rostrata* (Wallich). — Valves rostrate; beaks with a median row of puncta. TM. viii. p. 43, pl. 2. f. 5, 6. (VIII. 43.) India.

S. *lanceolata* (Wallich). — Valves acutely lanceolate, without median rows of puncta. TM. viii. p. 43, pl. 2. f. 7, 8. India.

2 * *Frustules naviculoid, enveloped in gelatine or enclosed in a definite tubular or gelatinous frond.*

Subfamily SCHIZONEMEÆ or LACERNATÆ.

This group is remarkable for the great external resemblance some of its species have to acknowledged Algæ, widely as they differ in internal structure.

Genus FRUSTULIA (Ag.).—Frustules bacillar or navicular, immersed in an amorphous gelatinous substance. For the present we retain this genus in the Schizonemeæ, but believe that, in most if not all the species, the frustules are more like a Synedra than a Navicula, and want the central nodule of the latter.

† Striæ evident.

Frustulia *salina* (E.).—Very narrow linear, transversely striated; in front view with rounded ends, in lateral view suddenly acute. E Inf. p. 232. Saline springs, Germany.

2 † Striæ wanting, or very indistinct.

F. *Kützingiana* (Rab.).—Smooth, lanceolate, with truncate apices. Rab D. p. 35, pl. 8. f. 3. = *Synedra mucicola*, KB. p. 68, pl. 14. f. 5. On stones in a rivulet near Nordhausen.

F. *minuta* (Rab.). — Minute, linear, smooth, in front view with truncate apices; valves with acutely cuneate ends. Rab D. p. 35. t. 8. f. 4. = *Synedra Frustulum*, KB. pl. 30. f. 77. Fresh water. Germany and Italy. It forms an olive-brown gelatinous mass on stones, and becomes green in drying.

F. *torfacea* (Braun). —Rhomboid-lanceolate, with obtuse apices, a stout median rib, and small central nodule. Rab D. p. 50, t. 7. f. 2. Germany. It forms dirty-yellow, rather firm, smooth or rugged gelatinous masses about plants in bogs. An authentic specimen from Professor Braun appears to us identical with *Navicula rhomboides*.

F. *Saxonica* (Rab.). — Slenderer than *F. torfacea*, with valves more acute; front view linear, with broadly rounded ends. Rab D. p. 50, t. 7. f. 1. Saxony. Forms dirty-olive-brown tremulous jelly-like masses in little cavities of damp rocks.

F. *Hæckeriana* (Rab.).—Valves spindle-shaped, with acute, pointed ends; front view narrow-lanceolate, with obtuse apices. Rab D. p. 50, pl. 10. f. 14. Germany. Forms dirty gelatinous masses on moss in streams.

F. *acicularis* (E.). — Bacilla slender, smooth, with acute apices; valves more acute, like a fine needle. ERBA. 1853, p. 527. Marine. Kingston Bay. Frustules like those of *Fragilaria Rhabdosoma*, but free and heaped together without order.

F. *bacillaris* (E.).—Bacilla linear, pinnulate, with truncate apices in the front, and rounded in the lateral view. EB. 1853. Marine. Kingston Bay. This species, like *F. acicularis*, seems included in gelatine dilated like an ulva, which, when dry, appears membranaceous. In the same membrane both species are included, with many other Diatomaceæ.

Genus MASTOGLOIA (Thwaites).—Frustules oblong, naviculoid, annulate, in a gelatinous mammillate cushion or frond; annuli loculated; loculi opening by foramina along the line of suture. "The frustules of Mastogloia are notably distinct from those of the other genera of this tribe, having the annulate structure of Rhabdonema with the canaliculi of Surirella." "The canaliculi are, however, formed differently from those of Surirella, not being connected with the valve, but with the annulus, which projects as a septum into the body of the frustule. The frustule itself is ordinarily excentric to the mucus developed around it, and sits as it were on the summit of a little nipple-like cushion of gelatine" (Smith).

Mastogloia *Dansei* (Thwaites). — Valves elliptic-oblong, with 8 to 20 loculi; striæ 42 in ·001″. SD. ii. p. 64, pl. 62. f. 388. = *Dickieia Dansei*, ANH. 1848. Brackish water. Britain. (xv. 30.)

M. *lanceolata* (Thw.).—Valves oblong-lanceolate, with subacute apices and 8 to 30 loculi; striæ 42 in ·001″. SD. ii. p. 64, pl. 54. f. 340. Brackish water. Britain.

M. *Smithii* (Thw.). — Valves oblong-lanceolate, with produced, obtuse or capitate apices, and 6 to 24 loculi; striæ 42 in ·001″. SD. ii. p. 65, pl. 54. f. 341. Fresh or brackish water. Britain.

M. *apiculata* (S.). — Valves elliptic-lanceolate, with slightly produced, obtuse, conic apices, and 30 to 50 loculi; striæ 42 in ·001″. SD. ii. p. 65, pl. 62. f. 387. Marine. Britain.

M. *Grevillii* (S.).—Valves linear, with obtuse, cuneate ends, and 15 to 20 loculi; striæ moniliform, 24 in ·001. SD. ii. p. 65, pl. 62. f. 389. Fresh water. Britain.

M. *minuta* (Grev.). — Valve elliptic-lanceolate or elliptic-oval, conspicuously apiculate; loculi 12 to 18; striæ very fine and close. Trinidad. Grev. MJ. v. p. 12, pl. 3. f. 10. It is a species evidently allied to *M. apiculata*, but differs in being scarcely half the size, and essentially in the much larger loculi; it is also much more apiculate.

Genus PHLYCTÆNIA (Kütz.).—Frustules navicular, included in (globose) gelatinous cells. Marine.

PHLYCTÆNIA *minuta* (K.).—Parasitic; cells hyaline, achromatic, solitary, scattered, or binately approximate and aggregated; included naviculæ few, binately or quaternately conjoined, smooth; front view linear, with truncate apices; valves broadly lanceolate, with acuminated ends. KSA. p. 96. Adriatic Sea.

P. *maritima* (E., K.). — Naviculæ smooth (?), linear, with rounded ends contained in distinct, but contiguous, gelatinous cells. KA. p. 96. = *Frustulia maritima*, E Inf. p. 232. Near Gothenburg. 1-1200″ to 1-1150″. This species occurs as a brownish jelly-like mass on stones. In the gelatinous cells Ehrenberg observed from one to twenty frustules.

Genus DICKIEIA (Berkeley).—Frond subgelatinous, plane, attenuated towards the base, containing scattered, navicular, imperfectly silicious frustules. Marine. Dickieia is distinguished by its plane frond and scattered frustules.

DICKIEIA *ulvoides* (Berk.). — Frond undivided; valves elliptical. ANH. xiv. pl. 9; SBD. ii. p. 66, pl. 54. f. 342. Britain. (xv. 31.) Frond linear or obovate-stipitate; striæ obscure, 36 in ·001″; nodule transverse, Sm.

D. *pinnata* (Ralfs). — Frond divided; valves elliptic-lanceolate. ANH. 2nd ser. viii. pl. 5. f. 6; SBD. ii. p. 66, pl. 54. f. 343. Britain. Autumn. Divisions of frond subpinnate; striæ obscure, 40 in ·001″; nodule punctiform, Sm.

Genus RHAPHIDOGLŒA (Kütz.).—Frond globose, gelatinous, tender, filled with fusiform bundles of naviculæ disposed in radiating threads. Marine. "The principal character of this genus is taken from the amorphous disposition of the gelatinous substance in which the frustules are immersed. The frustules are mixed together in a disorderly manner in Berkeleya, whilst in Rhaphidoglœa they are arranged in fusiform fasciæ, confluent by the pointed extremities" (Meneg.). We think this genus might, without inconvenience, be united with Berkeleya.

RHAPHIDOGLŒA *medusina* (K.). — Minute; fascicles lanceolate-acuminate, in irregular, reticulately-branched, continuous, radiating threads; naviculæ lanceolate. KB. p. 110, pl. 22. f. 7. Mediterranean Sea. 1-600″.

R. *manipulata* (K.). — Globose, pisiform; rays of fascicles reticulated, not interrupted; naviculæ linear-lanceolate, obtuse. KB. p. 110, pl. 22. f. 5. Europe. 1-700″ to 1-290″.

R. *interrupta* (K.). — Pisiform, with slender rays of fascicles, interrupted in a joint-like manner, with gradually tapering branches; naviculæ linear, slightly attenuated at the truncate apices. KB. p. 110, pl. 22. f. 6. Adriatic Sea. 1-300″.

R. *micans* (Lyngb., K.).—Subglobose; rays of the larger fascicles irregular, obsolete; naviculæ linear-lanceolate, subulate, rather acute, elongated. KB. p. 110, pl. 22. f. 8. = *Schizonema micans*, AD. p. 17; *Naunema micans*, E Inf.; *Frustulia costata*, Lobarzeusky in Linnæa, 1840, pl. 5. f. 1. Europe. Mr. Tuffen West informs us that, from careful observation of living specimens, he is satisfied that this species is identical with *Amphipleura pellucida*, in which opinion the late Prof. Smith fully concurred.

Genus BERKELEYA (Grev.). — Frustules naviculoid, linear-lanceolate, included within tubular submembranaceous filaments, which are free at their extremities, but immersed below in a more or less definite tubercle. Marine. Berkeleya differs from Schizonema in having the base of the filaments immersed in an orbicular gelatinous tubercle. This tubercle is at first firm and definite, but finally, especially when growing on rocks, becomes enlarged, soft, and often somewhat indefinite.

BERKELEYA *fragilis* (Grev.). — Filaments subsimple, minute; frustules crowded, slender, lanceolate or linear-lanceolate, with the striæ obsolete or wanting. GBF. p. 416; SD. ii. p. 67, pl. 54. f. 344. On Zostera, Algæ, and rocks. Europe. The gelatinous tubercle during growth becomes attenuated and more diffused, and sometimes forms an indefinite slimy covering about the base of the filaments. In a dried state this species acquires a metallic lustre.

B. *Adriatica* (K.).—Filaments branched; branches distinctly subdivided; frustules narrowly linear-lanceolate, rather obtuse. KB. p. 109, pl. 22. f. 4. Adriatic Sea. (XIV. 34, 35.) 1-300″. Scarcely distinct from *B. fragilis*.

Genus COLLETONEMA (Bréb.).—Frustules naviculoid, arranged in series within a tender, simple or divided, filiform or globose frond. Aquatic. According to Professor Smith, "the freshwater habitat and slightly divided frond distinguish the present genus from Schizonema; and [he adds] the frustules are also more firmly siliceous than those of that genus, and the character of the valve can usually be well seen after maceration in acid." Professor Kützing describes Colletonema as having a filiform frond composed of series of naviculæ held together and enveloped by an amorphous gelatinous mucus, without an exterior gelatinous tube. We doubt if any of the above characters sufficiently distinguish Colletonema from the allied genera, because they are either inadmissible in generic definitions, uncertain, or not peculiar to the genus. The absence of an external tube, if constant, would be of generic importance; but we sometimes find the frustule contained within an evident (although tender and evanescent) tube, whilst in Micromega, on the other hand, the presence of an external tube is sometimes doubtful. The fronds are exceedingly thin and tender, readily permitting the escape of their frustules, which may then be mistaken for species belonging to other genera; thus Professor Smith remarks that it is possible that *Pinnularia radiosa* may be merely the free state of *Colletonema neglectum*, and *Navicula crassinervia* the same condition of *C. vulgare*.

COLLETONEMA *eximium* (Thw., K.). — Frond filiform; frustule in lateral view sigmoid, striated. KA. p. 891; SD. ii. p. 69, pl. 56. f. 350. = *Schizonema eximium*, ANH. 1848; *Gloionema sigmoides*, EB. 1845; *Encyonema sigmoides*, KA. p. 62. ? Britain, Demerara ? Valves linear, sigmoid from the ends sloping in opposite directions; striæ 56 in ·001″. (VIII. 43.)

C. *viridulum* (Bréb.).—Frond filiform; naviculæ spirally and densely arranged; valves lanceolate, rather obtuse, smooth; front view linear-oblong, slightly and gradually attenuated towards the truncate apices. KA. p. 105. France.

C. *lacustre* (Ag., K.).—Frond filiform, simple or subramose, finer than a hair, enclosed in an imperceptible membrane; naviculæ elliptic or parallelogramic, in a single or double series. KSA. p. 105. = *Schizonema lacustre*, Ag CD. p. 18. Sweden. Tufts erect, brownish yellow; in size and habit like *Sphacelaria cirrosa*.

C. *vulgare* (Thw.). — Frond filiform, simple or divided, gradually tapering, containing one or two regular rows of frustules; valves oblong-lanceolate, with slightly contracted, obtuse ends. SD. ii. p. 70, pl. 56. f. 351. = *Schizonema vulgare*, ANH. 1848. England and France. Less common, according to Professor Smith, than the next species. Striæ 72 in ·001″.

C. *neglectum* (Thw.).—Frond slightly divided, obtuse, containing numerous and closely packed frustules; valves lanceolate, with obtuse ends. SBD. ii. p. 70, pl. 56. f. 352. = *Schizonema neglectum*, ANH. 1848. England.

C. *subcohærens* (Thw.).—Frond globose, gelatinous, pervaded by irregular rows of frustules; valves oblong, with rounded apices. SD. ii. p. 70, pl. 56. f. 353. Dorset. Striæ 28 in ·001″. In the character of its frond this species somewhat agrees with Rhaphidoglœa; but the frustules are arranged in series, not in fascicles, as in that genus.

Doubtful Species.

C. ? *amphioxys* (E., K.).—Known only from fragments. Naviculæ parallelogramic, smooth; valves acutely lanceolate. KSA. p. 105. = *Naunema amphioxys*, EA. pl. 3. 2. f. 5. Mexico. (XII. 55–57.)

C. ? *Americanum* (E., K.).—Naviculæ striated, large, linear, with subacute apices, densely arranged within branched tubes. KA. p. 105. = *Naunema Americanum*, EB. 1845, p. 79. River Hudson. Striæ 18 in 1-1200″.

Genus SCHIZONEMA (Ag., Kütz.) (Monema, *Grev.*; Monnema, *Meneg.*; Naunema, *Ehr.*),—Frustules naviculoid, arranged confusedly or in a single file, within a capillary, submembranaceous, single-tubed, more or less branched frond, of nearly equal diameter throughout. This genus, constituted by Agardh, has been repeatedly divided and reunited, and the generic names altered and transposed in an arbitrary manner without regard to priority. Dr. Greville founded Monema for the species with single tubes, retaining those with compound fronds in Schizonema. This division seems judicious, and indeed has been adopted by nearly every succeeding writer, although Greville's names have been disused or differently applied. Agardh recognized the distinctions, but retained Schizonema for the species with a frond of simple structure, and founded Micromega for the species having a compound structure. As this arrangement has been followed by Kützing, and acquiesced in by Greville, we use it here. There is the greatest difference, however, in the distribution of the species, even amongst those who admit both genera. "This discordance of opinion," observes Meneghini, "as to the arrangement of some species in one or other of the two genera, which, independently of their names, appear so distinct and so clearly defined, arises from the great difficulty of discerning the parallel tubes including the particular series of naviculæ. In some species the wall of the external tube is clearly distinct, and the naviculæ are confused within; but in some others it seems as if, instead of a tube, there were a mucous mass in which the naviculæ are immersed." Professor Smith considered that "this great diversity of opinion owes its origin to the variableness and inconstancy of the characters adopted by the writers who arranged the species under two genera. The presence of only one or of many files of frustules is certainly, to some extent, dependent upon the stage of growth of the specimen examined; and the appearance of secondary tubes within the general mucus-envelope is more or less apparent in different portions of the same frond, or according as it is examined in the fresh or dry state. A very extensive comparison of specimens leads me to believe that in every case where the development of the frond is much advanced, as in the older or basal portions, numerous files of frustules may be observed." For these reasons Professor Smith united the genera and divided Schizonema into two sections, "the first having frustules firmly siliceous, and fronds, in consequence, somewhat setaceous and robust; and the second including those species whose frustules are flaccid and delicate in character." As we consider the diagnostic differences sufficient, we have retained, with slight alteration, the arrangement of the species in these genera given by Meneghini in his memoir upon the Diatomaceæ. The frond in Schizonema is generally densely tufted and more sparingly branched than in Micromega. It is always single-tubed, and usually very slender, with even, parallel margins. The ends of the filaments, which in the early state are often empty, finally become ruptured and permit the escape of the naviculæ. In a recent state these characters will generally suffice to determine the genus, even before minute microscopic examination. We place more reliance upon colour in the discrimination of species than some writers allow. The colour for the most part depends upon the contents of the frustules, and, according to our experience, is subject to little variation, except in old specimens rendered unfit for comparison by the escape of the naviculæ.

* *Central nodule transversely dilated.*

SCHIZONEMA *cruciger* (S.).—Filaments much divided; naviculæ crowded; valves lanceolate, acute, striated; median nodule transversely dilated into a stauros. SD. ii. p. 74, pl. 56. f. 354. Britain. Striæ distinct, 40 in ·001″.

2 * *Central nodule punctiform, sometimes obsolete.*

S. *Grevillii* (Ag.). — Frond membranaceous, much branched, level-topped; naviculæ in front view subquadrate; valves oblong-lanceolate, with 60 striæ in ·001″. Ag CD. p. 19; SD. ii. p. 77, pl. 58. f. 364. = *Monnema Grevillii*, Meneg.; *S. quadripunctatum*, Harv. On rocks and mud. Fronds densely tufted, brown, turning to a dirty verdigris-green when dried, and adhering imperfectly to paper. Naviculæ large, crowded at base, in a single file near the extremities. *S. quadripunctatum* of British writers is an old state, and turns of a rusty colour in drying. 1-576″.

S. *crinoideum* (Harv.). — Filaments very slender, achromatic, sparingly branched, densely woven into a pale-green or brownish stratum; naviculæ very minute, disposed in an irregular loose series. Harv. Manual, p. 214. = *S. tenellum*, KB. p. 111, pl. 23. f. 8; *Monnema quadripunctatum*, Meneg. Europe. Filaments exceedingly slender, with long, simple, flexuose branches. Brown when recent, olive-green and glossy when dry. 1-1386″.

S. *Dillwynii* (Ag.). — Frond densely tufted, rich brown, very slender; naviculæ minute; valves lanceolate-acute, smooth. SD. ii. p. 77, pl. 58. f. 366. = *Monema Dillwynii*, GCF. pl. 297. Rocks, mud, and Algæ. Naviculæ imperfectly silicious, more or less crowded, especially near the extremities; fronds turning deep green on immersion in fresh water, and quickly acquiring an offensive smell; generally glossy when dried. 1-1000″.

S. *implicatum* (Harv.). — Frond capillary, densely tufted, much branched, curled, and entangled; naviculæ very minute, irregularly crowded; valves lanceolate, rather obtuse. SD. ii. p. 78, pl. 59. f. 367. On mud in sheltered places. Tufts of a duller brown than *S. Dillwynii*, gradually turning in fresh water to a dark olive-green, not quickly becoming offensive. Frustules in form and size similar to those of *S. rutilans*.

S. *dubium* (Harv.). — Resembles *S. Dillwynii*; but the long branches, naked below, are furnished towards their summits with numerous curled ramuli. Harv. Manual, p. 212. = *S. Dillwynii β*, KA. p. 101. Rocks, &c. Tufts unequal-topped; apices of ramuli acute; naviculæ very minute and densely packed.

S. *virescens* (Harv.). — Fronds very slender, densely tufted, tenacious, very much branched from the base; ramuli numerous, curled, upper ones longest, swelling towards the tips, which are dark-coloured and end in a sudden point; naviculæ minute. Harv. Manual, p. 212. North Devon. Tufts dense, brownish olive, not much altered in drying. Under the microscope it has much the appearance of *S. Dillwynii*; but the thickened, dark-coloured tips are remarkable.

S. *rutilans* (Trentepohl, Ag.).—Densely tufted; filaments elongated, subsimple, brownish and empty at base, hyaline and filled with crowded linear-oblong frustules at the apex; when dry, shining and reddish. Ag CD. p. 18; KB. p. 112, pl. 23. f. 6. 1, 2. = *Monnema rutilans*, Meneg. "It differs from *S. Dillwynii* by its more varnish-like lustre, reddish colour when dry, and finer and more simple filament" (Ag.).

S. *Hoffmannii* (Ag.). — Filaments tufted, subsimple, arachnoid, when dry shining with a reddish lustre; naviculæ small, smooth, crowded; valves lanceolate. = *S. rutilans*, var. *Hoffmanni*, KB. pl. 23. f. 10; *Monnema Hoffmanni*, Meneg. Europe, Aberdeen. (x. 207.) Professor Kützing makes this form a variety of *S. rutilans*; but Meneghini observes that they differ in external characters and in the dimensions and shape of the naviculæ. 1-1080″ to 1-960″.

S. *Balticum* (E.).—Naviculæ striated, slender, linear-lanceolate, in front view truncate, in lateral view subacute, dense, crowded in the intricately branched filaments. E Inf. p. 236, pl. 20. f. 15. = *S.*

rutilans, var. *viride*; *Monnema octocarpöides*, Meneg. Europe, England. 1-1200″.

S. *Ehrenbergii* (K.).—Frond parasitic, lubricous, tufted, green, branched; branches crystal-hyaline, soft, obtuse at the apex; naviculæ (in dried specimens) inconspicuous, tender, arranged in obsolete series, oblong in one view, truncate in the other, with rounded ends. KB. p. 113, pl. 23. f. 9.=*Naunema Dillwynii*, E Inf. p. 235, pl. 20. f. 13. Europe. 1-1320″.

S. *spadiceum* (Grev.).—Filaments capillary, tufted, much branched, of a reddish olive-green colour; ramuli much divaricated, ultimate ones patent; naviculæ linear-oblong, elongated. Grev. in Hooker's Br. Fl. p. 412. Scotland. Fronds often with a faint metallic lustre when dry. Filaments very slender, and of nearly equal thickness throughout.

S. *Adriaticum* (Ag.).—Filaments finer than a hair, elongated, subsimple, when dried of an opaque olive green; naviculæ narrow, lanceolate. AgCD. p. 21. Venice.

S. *confertum* (S.). — Frond filiform, sparingly divided throughout; naviculæ exceedingly crowded; valves shortly lanceolate, acute, with indistinct, marginal striæ. SD. ii. p. 75, pl. 57. f. 359. Aberdeen. ·0008″ to ·0011″.

S. *lutescens* (K.).—Tufted, when dry of a reddish colour, glossy; filaments subsimple, capillary, coloured and empty at base, hyaline and filled with naviculæ at the apex; naviculæ oblong-lanceolate, obtuse. KB. p. 112. Europe. 1-1200″.

S. *flavum* (K.).—Frond tufted, lubricous, yellow; filaments tenacious, crystalline, achromatic, straight, fastigiate, branched; branches attenuated at the apex, erect; naviculæ scattered or interruptedly aggregate, oblong or linear, with obtuse or truncate ends. KSA. p. 101. France. Naviculæ rather broad.

S. *luteum* (K.).—Frond tufted, yellow; filaments achromatic, capillary, subfragile, nearly equal throughout; naviculæ linear or acicular, inconspicuous, alternately loosely and densely compacted. KA. p. 102. France. 1-1080″.

S. *sordidum* (K.). — Fronds minute, tufted, parasitic, dull brownish-grey; filaments subdichotomous, achromatic, with equal branches; naviculæ slender, truncate; valves lanceolate-linear, rather obtuse. KB. p. 113, pl. 24. f. 1.=*Monnema sordidum*, Meneg. On Zostera. Europe. 1-1440″ to 1-1200″.

S. *tenue* (Ag.).—Filaments arachnoid, irregularly branched; naviculæ elliptic, disposed almost in a single series. KB. p. 112, pl. 23. f. 2. = *Monnema tenue*, Meneg. Adriatic Sea. When dried it appears as a sulphur-green stain; filaments inconspicuous from their tenuity, Ag. Professor Kützing refers Agardh's species to his *S. mucosum*, but we doubt their identity.

S. *simplex* (E., K.). — Frond subsolitary; naviculæ smooth, oblong, with rounded ends, in a simple series within flexible filiform tubes. KA. p. 99. = *Naunema simplex*, E Inf. p. 234, pl. 20. f. 12; *Monnema inconspicuum*, Meneg. p. 436? Adriatic Sea. 1-1150″ to 1-570″.

S. *Lenormandi* (K.).—Parasitic, short, subsimple, in woolly tufts; filaments achromatic, for the most part with empty apices; naviculæ quadrangular, arranged in a simple series. KA. p. 99. = *Monnema Lenormandi*, Meneg. France. Allied to *S. tenue*, but with smaller frustules, Meneg.

S. *tenuissimum* (K.). — Filaments crisped, subramose, hyaline, very slender, densely interwoven into a compact, brown mucous stratum; naviculæ very minute, linear, truncate, in obsolete series. KB. p. 111, pl. 23. f. 111. 1–3. =*Monnema tenuissimum*, Meneg. Adriatic Sea.

S. *striolatum* (K.). — Fronds tufted, green, crisped, capillary, fastigiately branched; filaments transversely striated, nearly empty at the base, filled at the apex, crystal-hyaline throughout; naviculæ oblong, obtuse in the lateral, truncate in the front view. β *clavigerum*, branches irregular, covered with obovate or clavate ramuli. KB. p. 114, pl. 26. f. 2. = *Monnema striolatum*, Meneg. Germany and France.

Genus MICROMEGA (Ag., Kütz.) (=Schizonema, *Meneg.*). — Frustules naviculoid, arranged in two or more longitudinal series within a gelatinous, filiform or setaceous frond, or contained within tubes united longitudinally into a compound, often membranaceous frond. Micromega is distinguished from Schizonema by its compound frond. We believe that under one genus have been comprised species belonging to two distinct types, which perhaps ought to form two genera.

The first contains species having series or files of naviculæ surrounded by a gelatinous covering, and by their union forming a compound, generally stout frond, externally furnished with a common epidermis. Type, *M. Smithii*. The species of this section are highly gelatinous, and consequently adhere firmly to paper in drying, are frequently of considerable thickness at the base, and often have their extremities lobed, proliferous, or penicillate. The margins, especially in old specimens, are generally more or less rough or irregular. The frustules are released by the destruction of the gelatine, and not by injury to the extremities, as in the case of tubular fronds. Each series of frustules seems to have its own proper gelatinous covering, and the junctions are marked by faint longitudinal lines; but these, which have been supposed to indicate tubes, are often very indistinct; hence arises much of the difficulty in determining their proper genus.

The second section contains species which have a strictly compound frond of distinct tubes longitudinally connected, each tube similar to a frond of Schizonema. The fronds are generally membranaceous, and adhere imperfectly to paper; the frustules, arranged more or less irregularly in their tubes, are liable to escape from an opening at any part. Type, *M. cornoides*. If these sections, as is probable, should hereafter rank as genera, the three allied genera might be named and characterized as follows:—

1. Monnema (Grev., Meneg.) (=Schizonema, *Ag.*, *Kütz.*).—Frond tubular, single-tubed.

2. Schizonema (Ag., Grev., Meneg.) (=Micromega, *Ag.*, *Kütz.*). — Frond gelatinous, not tubular.

3. Micromega (Ag., Ehr.).—Frond tubular, two- or more tubed. The branching in Micromega, especially in the species belonging to the first section, results from the separation of the series of naviculæ, and is not the branching of a tube, as in Schizonema.

* *Frond gelatinous, containing longitudinal series of naviculæ.*

Micromega *Smithii* (Ag.). — Frond robust, setaceous, gelatinous, firm, simple below, much branched above, frustules in longitudinal series; valves lanceolate, acute; striæ 40 in ·001''. = *Schizonema Smithii*, AD. p. 18; SD. ii. p. 76, pl. 57. f. 362. Rocks and Algæ. Common. Fronds usually scattered, pale-yellowish olive; naviculæ disposed in subdistant files within the colourless jelly of the frond. 1-600''.

M. *helminthosum* (Chauv.). — Fronds robust, setaceous, gelatinous, lubricous, tufted, much branched, with acute apices; naviculæ in longitudinal series; valves elliptic-oblong, with rounded ends; striæ 48 in ·001''. = *Schizonema helminthosum*, AD. p. 20; KA. p. 103; SD. ii. p. 74, pl. 56. f. 355; *S. Arbuscula*, KB. pl. 27. f. 1; *Naunema Arbuscula*, E Inf.; *N. fruticulosum*, KA. p. 104. Rocks. Colour olive-brown, becoming greenish-grey and without gloss in drying. 1-504''. It may be known from *M. Smithii* by its more tufted, often gregarious, lubricous and darker-coloured fronds, and its larger and very obtuse valves.

M. *torquatum* (Harv.).—Frond robust, simple below, much divided above, ultimate divisions much twisted; naviculæ in longitudinal files; valves oblong-lanceolate; striæ 40 in ·001''. = *Schizonema torquatum*, Me.; SD. ii. p. 76, pl. 57. f. 361; *S. Smithii*, *β. torquatum*, Harv. Manual, p. 211; *Micromega setaceum*, *γ. torquatum*, KA. p. 107. Britain. In size and colour it agrees with *M. Smithii*, but is remarkable for having its branches curled; its naviculæ are more distinctly in chains, shorter and broader in proportion to their length than in that species. 1-720'' to 1-690''.

M. *Polyclados* (K.).—Frond setaceous, dichotomously branched; branches elongated, slender, rather rigid; naviculæ (membranaceous ?), flaccid, in distinct tubes. KB. p. 118, pl. 28. f. 1. Europe. Spermatia elliptic. 1-1080'' to 1-960''. Meneghini unites this form with *M. torquatum*.

M. *nebulosum* (Me.). — Frond slightly greenish, cloudy, subachromatic, forming an intricate mucous stratum; tubes gelatinous, achromatic, obsolete; naviculæ slender-lanceolate, rather obtuse, loosely scattered. = *Schizonema nebulosum*, KA. p. 99. Dalmatia. "Kützing is right in remarking that my *Schizonema nebulosum* corresponds to *M. torquatum* in the form and dimensions of the naviculæ. Although when dried upon paper it only forms a light cloud, yet, when diligently examined, it proves similar in ramification to Harvey's species" (Me. p. 445). 1-1080″.

M. *Wyattii* (Harv.). — Frond cartilaginous, setaceous at base, much branched; branches capillary, erect, straight, with acute axils, tapering to a fine point; naviculæ lanceolate, densely packed in jelly. = *Schizonema Wyattii*, Harv. Manual, p. 211. England. Forms globose tufts. This species comes near *S. Smithii*, but is much more slender, and opens more readily and with greater elasticity after being dried.

M. *molle* (S.). — Frond gelatinous, simple below, membranous by cohesion above; margin much divided, into acute segments; naviculæ in crowded files; valves lanceolate, acute, with 48 striæ in ·001″. = *Schizonema molle*, SD. ii. p. 77, pl. 58. f. 365. Britain. ·0012″ to ·0015″. The naviculæ are very like those of *M. helminthosum*, but the form and structure of the frond are altogether different. The frond is soft and flaccid, but the naviculæ are firmly silicious.

M. *divergens* (S.).—Frond simple below, sparingly divided or by cohesion irregularly submembranous above; valves oblong-lanceolate, with 42 striæ in ·001″. = *Schizonema divergens*, SD. ii. p. 76, pl. 57. f. 363. Larne Lough. ·0013″ to ·0018″. Remarkable for the diffused arrangement of the primary divisions. The species is closely allied to *M. Smithii* and *M. torquatum*.

M. *sirospermum* (K.). — Frond rather stout, rigid, olive, cartilaginous, much branched; branches unequal, irregular, curved, setaceous; naviculæ lanceolate, in dense series, often inflated into globose; spermatia concatenate. KA. p. 109. = *Schizonema sirospermum*, Me. England. Perhaps a state of *M. Smithii*. 1-720″.

M. *setaceum* (K.). — Frond setaceous, olive, rigid, subdichotomous; branches, lateral and terminal, abbreviated, spine-like; naviculæ in crowded series; valves lanceolate, acute. KB. p. 117, pl. 25. f. 2, 3. = *Schizonema setaceum*, Me. Adriatic Sea. 1-720″ to 1-696″. Spermatia elliptic-globose.

M. *corymbosum* (Ag., K.). — Frond arborescent, rather stout at the base, firm, rigid, yellowish, much branched; branches setaceous, rigid, here and there corymbose; naviculæ in distinct, close series; valves elliptic-lanceolate. KB. p. 117, pl. 27. f. 9. = *Schizonema corymbosum*, AD. p. 21. England. 1-960″.

M. *hydruroides* (K.).—Fronds greenish or brown, ultra-setaceous, rigid; branches elongated; ramuli fasciculated, capillary; naviculæ in close series, minute, rather broad; valves with rounded ends. = *Schizonema hydruroides*, KB. p. 114, pl. 26. f. 7. Heligoland. 1-1380″.

M. *Bryopsis* (K.).—Frond green, setaceous, rigid, branched; branches scattered, superior ones patent, obtuse; naviculæ oblong, truncate in front, and rounded in lateral view. = *Schizonema Bryopsis*, KB. p. 114, pl. 26. f. 8. Heligoland. 1-680″.

M. *trichocephalum* (K.).—Frond greenish-yellow, ultra-setaceous, rigid, tufted, sparingly branched; inferior branches scattered, simple; terminal ones crowded, curved, subulate, capitate; naviculæ in very close series, minute. = *Schizonema trichocephalum*, KB. p. 114, pl. 27. f. 3. Heligoland. 1-1440″.

M. *capitatum* (K.).—Frond pale green, setaceous; branches elongated, slender, virgate, with a corymbose, capitate, acute apex; naviculæ in distinct series, minute; valves lanceolate. = *Schizonema capitatum*, KB. p. 114, pl. 27. f. 4. Heligoland. 1-1200″.

M. *myxacanthum* (K.). — Less stout than *M. corymbosum*, gelatino-cartilaginous, pale brown; branches diverging, attenuated at the base, digito-multifid at the apex; divisions patent, acute; series of lanceolate naviculæ at base few and loose, above more numerous, crowded at the apex. KB. p. 117, pl. 24. f. 8. = *Schizonema myxacanthum*, Me. Adriatic Sea.

M. *aureum* (K.). — Frond arborescent, setaceous at base, rather rigid, ochraceous-yellow, much branched, fastigiate; branches capillary, pale, mucous; series of naviculæ and tubes distinct, crowded; valves lanceolate. KB. p. 117, pl. 27. f. 8. = *Schizonema aureum*, Me. Sidmouth. 1-960″.

M. *obtusum* (Grev.). — Frond robust, setaceous, elastic, firm, irregularly dichotomous, with rounded axils and obtuse apices; naviculæ minute, crowded in irregular files; valves elliptic-oblong. = *Schizonema obtusum*, Grev BF. vi. pl. 302; SD. ii. p. 78, pl. 58. f. 368. Britain. The naviculæ are excessively crowded, and we are uncertain whether this species ought not rather to be placed in Schizonema. "Frond thicker than a hog's bristle, and nearly of equal diameter throughout; colour brownish-yellow, becoming yellowish-green in dying. A handsome and distinct species, well marked by its roundish axils and obtuse apices" (Harvey).

M. *Blyttii* (Ag.). — Frond elongated, filiform, many times irregularly dichotomous, with rounded axils, cylindrical, not attenuated; naviculæ in numerous parallel series. AD. p. 23. = *Schizonema Blyttii*, Me. Norway. An elegant and remarkable species; fronds erect.

M. *mesoglœoides* (K.). — Frond stout, very gelatinous, greenish, irregularly branched; branches dense, numerous, unequal; ramuli incrassated at the apex, patent; naviculæ rather irregularly aggregated, dense; valves with attenuated apices. = *Schizonema mesoglœoides*, KA. p. 103. Aberdeen. 1-600″.

M. *humile* (K.).—Frond parasitic, very short, tufted, erect, subramose; branches with obtuse, hyaline empty apices; naviculæ acute, linear-lanceolate, arranged in two to four series. = *Schizonema humile*,. KB. p. 111, pl. 23. f. 7. Adriatic Sea. Naviculæ in front view linear, truncate. 1-1200″.

M. *papillosum* (Me.). — Frond parasitic, small, very mucous, green; filaments ultra-setaceous, subsimple or furnished with acute spiniform ramuli, everywhere covered with very minute, regularly disposed papillæ; valves narrow-elliptic, rather obtuse. = *Schizonema papillosum*, Me. p. 452. Dalmatia. Naviculæ in series, four times as long as broad, in front view slightly elliptic, with truncate ends. The papillæ appear hemispherical or slightly conical, and are arranged in quincunx, Me.

M. *Stalianum* (Me., K.).—Fronds parasitic, gelatinous, green or greenish-brown; filaments setaceous, elongated, irregularly branched; branches diverging, short; naviculæ in series, six times as long as broad; valves elongated-elliptic, obtuse. KA. p. 106. = *Schizonema Stalianum*, Me. p. 452. Dalmatia. Is very mucous and adheres strongly to paper; naviculæ in front view exactly linear. 1-420″ to 1-360″.

M. *Corinaldi* (Me.).—Frond parasitic, small, green; filaments subsimple, setaceous; frustules minute, five times as long as broad; valves narrow-elliptic. = *Schizonema Corinaldi*, Me. p. 453. Marseilles. Naviculæ in series, in front view exactly linear. The threads, slightly mucous, are usually simple; the few ramifications are short and divaricate, Me.

M. *fastigatum* (K.).—Frond setaceous, olivaceous, much branched; ultimate branches subcorymbose, with lanceolate-acuminate apices; naviculæ minute, oblong, obtuse, in loose series. KA. p. 108. Torquay. Secondary tubes obsolete.

M. *medusinum* (K.). — Frond cartilagino-gelatinous, hyaline, brown, turgid at the base, separated at the apex into penicillate fibres; series of naviculæ loosely entangled, intermixed with flexuose longitudinal fibres. KB. p. 118, pl. 25. f. 6. = *Schizonema medusinum*, Me. Adriatic Sea. Valves lanceolate.

M. *hyalinum* (K.).—Frond colourless, hyaline, gelatino-cartilaginous, soft, setaceous at base, much branched; branches attenuated, capillary, empty at the apex; series of naviculæ few, loose, intermixed with a few fibres; naviculæ minute; valves oblong-lanceolate, obtuse. KB. p. 117, pl. 24. f. 6. = *Schizonema hyalinum*, Me. Adriatic Sea. Naviculæ 1-960″ to 1-780″; in front view truncate.

M. *tenellum* (K.). — Frond colourless, hyaline, gelatino-cartilaginous, setaceous, branched, subdichotomous; branches delicate and empty at the apex; series of slender naviculæ and internal tubes distinct. KB. p. 117, pl. 24. f. 7. = *Schizonema tenellum*, Me. Adriatic Sea.

M. *Hyalopus* (K.).—Frond colourless and hyaline at the base, above greenish, narrow, much branched; branches fastigiate, subacute, full to the apices; lower series of naviculæ lax, superior crowded; valves lanceolate. KB. p. 117, pl. 25. f. 5. = *Schizonema Hyalopus*, Me. Adriatic and French Seas, Jersey. Internal tubes obsolete; naviculæ in front view oblong, truncate; spermatia immersed, globose.

M. *laciniatum* (Harvey). — Frond robust, setaceous below, incrassated above, very tender and gelatinous, cleft into numerous tapering branches; naviculæ very minute, in close files; valves elliptic-lanceolate, obtuse. = *Schizonema laciniatum*, Harv. Man. p. 210; SD. ii. p. 79, pl. 59. f. 371; *S. scoparium*, KB. p. 114, pl. 27. f. 7. Europe. Frond cleft above into numerous irregular jagged branches. 1-600″.

M. *parasiticum* (Griff., K.). — Frond gelatinous, capillary, tufted, much and intricately branched from the base; branches flexuose, with rounded axils; frustules crowded in distinct files; valves lanceolate, acute. KB. p. 116, pl. 27. f. 2. = *Schizonema parasiticum*, Harv. Man.

p. 213; SD. ii. p. 79, pl. 59. f. 371. Europe. Colour pale yellowish, sometimes brownish. Naviculæ 1-1380″.

M. *investens* (Montagne). — Fronds parasitic, minute, lubricous, brown, opaque, fasciculated; filaments dilated at the base, diffusely ramose; branches anastomosing; naviculæ large, in one or two series. = *Schizonema investens*, Mont. Annales des Sci. Nat. 1850, p. 308. Guiana. Naviculæ with two nuclei.

M. *mucosum* (K.).—Frond soft, highly mucous; filaments contiguous and confluent; branches irregular; naviculæ in few files; valves elliptic-oblong, with rounded ends, delicately striated. = *Schizonema mucosum*, KB. p. 115, pl. 26. f. 9; SD. ii. p. 75, pl. 57. f. 360. Adriatic Sea, England. This species can scarcely be the *Schizonema tenue* of Agardh, as Kützing has supposed.

M. *parvum* (Me.).—Frond olive-green, mucous; filaments hyaline, simple (?), much entangled and curved; naviculæ in distinct, loose, oblique or straight series; valves lanceolate. = *Schizonema parvum*, Me KA. p. 100. Venice, Cayenne. Naviculæ in front view linear, rectangular. 1-1200″.

M. *Meneghinii*. — Frond green, very gelatinous; filaments very hyaline, lubricous, fastigiately divided and laciniated; naviculæ lanceolate, in loose, rather distant series. = *Schizonema bombycinum*, Me KA. p. 100. Venice. 1-1200″.

M. *Kützingii*. — Fronds tufted, intricate, much branched; filaments hyaline, with rather acute apices; naviculæ in distinct series; valves lanceolate, acute. = *Schizonema floccosum*, KB. p. 113, pl. 24. f. 3. Germany. Naviculæ in front view oblong, truncate. 1-600″.

M. *crispum* (Mont.). — Fronds small, crisped, capillary, green, branched; filaments obtuse, dilated and multifid at the apex; naviculæ very minute, much crowded in obsolete series. = *Schizonema crispum*, KB. p. 113, pl. 29. f. 71. Auckland Islands.

M. *plumosum* (K.). — Frond tufted, wavy, rather curled, green, fastigiately branched; filaments densely filled at the ends, dilated, multifid; naviculæ distinct, very minute; valves oblong-elliptic, with rounded ends. = *Schizonema plumosum*, KB. p. 113, pl. 26. f. 1. Europe. Naviculæ in front view oblong, truncate. 1-1440″.

M. *Zanardinii* (Me.).—Frond very fine, pale green; filaments capillary, gradually separating into corymbose arachnoid branches of one series; naviculæ in loose series, four times as long as broad; valves elliptic. = *Schizonema Zanardinii*, Me. p. 453. Venice. Naviculæ in front view exactly linear. Fronds in globular tufts, which, dried upon paper, form uniform spots, in which the separate threads can only be distinguished by a lens. In its mode of ramification it resembles *M. flagelliferum*, Me.

M. *flagelliferum* (K.). — Fronds very minute, tufted, parasitic, floccose, capillary; branches erect, separated at the apex into flagelliform fibres; series of the very minute naviculæ and internal tubes distinct. KB. p. 116, pl. 24. f. 4. = *Schizonema flagelliferum*, Me. 1-1920″ to 1-1560″.

M. *floccosum* (K.). — Frond minute, subcapillary, branched, rather delicate, gelatinous; series of the long, obtuse and truncate naviculæ and internal tubes very distinct. KB. p. 116. Adriatic Sea. 1-720″.

M. *intricatum* (K.). — Frond delicate, subgelatinous, nebulose, pallid yellow, irregularly branched; branches patent, upper ones abbreviated; series of naviculæ loose, intermixed with very fine longitudinal fibres; naviculæ oblong, obtuse, very minute. KB. p. 116, pl. 26. f. 5. = *Schizonema intricatum*, Me. England. 1-1440″ to 1-680″.

M. *bombycinum* (K.). Frond pale yellow, contorted, twisted, much branched, capillary; naviculæ remotely concatenate, inconspicuous, and very minute. KB. p. 116, pl. 26. f. 6. = *Schizonema bombycinum*, Me. Europe. (XIV. 43, 44.)

M. ? *Agardhii* (E.). — Naviculæ very narrow, acute, arranged in a simple series within a proper tube; tubes fasciculately joined into a filament. = *Schizonema Agardhii*, E Inf. p. 238, pl. 20. f. 16. North Sea. (X. 208.) Professor Kützing unites this species with *M. bombycinum*; but the frustules are apparently (judging from the respective figures) much larger.

M. *patens* (K.).—Frond minute, parasitic, floccose-capillary, soft, gelatinous; branches divergent or patent, with obtuse apices; series of naviculæ and internal tubes distinct; naviculæ very minute. KB. p. 116, pl. 24. f. 5. = *Schizonema patens*, Me. 1-2400″.

M. *lineatum* (K.).—Frond decumbent, intricate, capillary, olivaceous, tenacious, lubricous, subramose; branches at the apex attenuated, curved, rather obtuse; series of the very minute lanceolate naviculæ distinct. KB. p. 116, pl. 23.

f. 4. = *Schizonema lineatum*, Me. Dalmatia. 1-1320" to 1-1200".

M. *gracillimum* (S.).—Frond capillary, simple below, sparingly branched and submembranous towards the apices; naviculæ crowded in irregular files; valves lanceolate, acute. = *Schizonema gracillimum*, SD. ii. p. 79, pl. 59. f. 372. Torquay. ·0009".

M. *Illyricum* (K.).—Fronds forming a dull-, obscure-green, mucous, intricate stratum; filaments very fine, simple (?), soft, hyaline; naviculæ acuminate, lanceolate, in dense series, indistinct when dried. = *Schizonema Illyricum*, KB. p. 111, pl. 22. f. 3. Trieste. 1-1680" to 1-1440".

M. *minutum* (K.). — Frond parasitic, very short, fine, decumbent, subramose; branches tapering to acute apices; naviculæ acute, lanceolate, in few (2 to 4) series. = *Schizonema minutum*, KB. p. 111, pl. 23. f. 5. Adriatic Sea. Naviculæ in front view linear. 1-1176".

2 * *Frond composed of tubes longitudinally connected.*

M. *comoides* (Grev.).—Filaments dirty brown, coarse, membranaceous, elongated, twisted, composed of parallel tubes; frustules crowded; valves oblong-lanceolate; striæ 48 in ·001". = *Schizonema comoides*, Grev. (scarcely of Agardh, certainly not the *Conferva comoides* of Dillwyn); Hook. Br. F. p. 413; SD. ii. p. 75, pl. 57. f. 358; *Schizonema araneosum*, KB. p. 113, pl. 25. f. 9. Flat rocks, often in vast quantities. It is very remarkable that this coarse, dirty-looking species should ever have been confounded with the *Conferva comoides*, Dillw. The latter, we were assured by Mr. Dillwyn, was totally unlike the present species, and was correctly described by him. Unfortunately Mr. Dillwyn was unable to find an original specimen of his species, but he believed that a very slender simple-tubed Schizonema, of a bright brown colour, which we once found in great abundance in April, on the rocks outside the Mumble Lighthouse near Swansea, was the true *Conferva comoides*. The present species is usually twisted in a rope-like manner, retains its colour in drying, is very opaque, and does not adhere to paper.

M. *ramosissimum* (Ag.).—Frond robust, firm, membranaceous, much branched; branches short, swelling upwards; frustules minute, densely arranged in distinct, parallel tubes; valves oblong-lanceolate. AD. p. 22. = *Schizonema ramosissimum*, Harv. Man. p. 210; SD. ii. p. 78, pl. 59. f. 369. Europe. Somewhat resembles *M. comoides* in appearance, but is less elongated and less twisted. Does not adhere to paper.

M. *apiculatum* (Grev., Ag.). — Frond robust, ultra-setaceous, cartilaginous, irregularly dichotomous; branches with clavate ends, terminated by a mucro; secondary tubes distinct; naviculæ minute, crowded; valves lanceolate. AD. p. 22; KB. p. 117, pl. 27. f. 10. = *Schizonema apiculatum*, AA. p. 11; Harv. Manual, p. 210. Scotland.

M. *corniculatum* (Ag.). — Frond very stout, cartilaginous, erect, rigid, subdichotomous, much branched above; ultimate ramuli subulate and spine-like; naviculæ slender, lanceolate, contained in distinct secondary tubes. AD. p. 24; KB. p. 118, pl. 28. f. 2. = *Schizonema corniculatum*, Me. Adriatic Sea. Habit of a small Fucus. 1-600".

M. *penicillatum* (Chauv., Ag.).—Frond thick and simple at the base, divided at the apex into very numerous, penicillate, fastigiate, capillary branches. AD. p. 23. = *Schizonema penicillatum*, Chauvin; *M. corniculatum β*, KA. p. 109. France.

M. *pallidum* (Ag.).—Frond pulvinate, rigid, subcartilaginous, stout, much branched; ramuli suberect, abbreviated, obtuse; naviculæ minute, in lax series within distinct secondary tubes. AD. p. 23; KB. p. 118, pl. 28. f. 3. = *Schizonema pallidum*, Me. Adriatic Sea. (xiv. 39-42.) Tufts hemispherical, dense; colour pallid, verging on brownish yellow. 1-720" to 1-696".

M. *chondroides* (K.). — Frond minute, cartilaginous, olive-coloured; terminal branches aggregated, clavate, obtuse, here and there with hair-like spines; series of naviculæ and secondary tubes very distinct, crowded; naviculæ membranous, flaccid, minute. KB. p. 118, pl. 25. f. 8. = *Schizonema chondroides*, Me. Adriatic Sea. 1-1380" to 1-1320". Spermatia immersed, globose.

M. *spinescens* (K.). — Frond dwarfish, setaceous, slightly dilated upwards; terminal ramuli acute, spine-like; series of naviculæ and secondary tubes crowded, very distinct; valves lanceolate. KB. p. 118, pl. 27. f. 11. = *Schizonema spinescens*, Me. Adriatic Sea. Naviculæ in front view oblong, truncate. 1-960" to 1-720". Spermatia internal, globose.

M. *albicans* (K.). — Frond setaceous, whitish or olive-green; branches and ramuli equal in thickness, fasciculated or whorled; naviculæ in distinct series, lanceolate; secondary tubes distinct. KB. p. 118, pl. 27. f. 12. = *Schizonema albicans*, Me. Adriatic Sea. 1-1200″ to 1-1080″. Meneghini describes the valves as broadly elliptic.

M. *Berkeleyi* (K.).—Frond tufted, dull olive-brown; filaments setaceous, rather rigid, branched; branches erect, attenuated; naviculæ large; valves elliptic-oblong, in very distinct secondary tubes. KA. p. 106. Torquay. Naviculæ in front view parallelogramic. 1-1080″.

FAMILY XIX.—ACTINISCEÆ.

Individuals silicious, furnished with radiating spines. Marine. The Actinisceæ bear little or no resemblance to the Diatomaceæ, and ought to be excluded from them. M. de Brébisson thinks they would be more appropriately placed near the Arcella, Euglypha, or some allied genus. On the other hand, Professor Bailey would refer them to the Polycystina.

Genus ACTINISCUS (Ehr.).—Frustules solid, star-like. Actiniscus differs from Dictyocha and Mesocena in having a solid centre or body from which rays, varying in number and form, diverge.

ACTINISCUS *Sirius* (E.). — Rays 6, acute, winged at the base. EM. pl. 33. 15. f. 1. 1-1150″. Alive, Norway; fossil, America. The rays seem to arise from the disc, and not from the margin.

A. *Pentasterias* (E.).—Rays 5, acute, not (or but partially) exserted. EM. pl. 35 A. 23. f. 1. 1-1150″. Alive, Norway; fossil, Greece and America.

A. *Tetrasterias* (E.).—Rays 4, acute, not (or but partially) exserted. EM. pl. 18. f. 62. 1-1008″. Virginia. The last two forms may be varieties of *A. Sirius*.

A.? *Stella* (E.). — Stellate, with 6, marginal, obtuse rays or teeth. = *Dictyocha*, E. 1838. Fossil. Europe and Africa.

A.? *quinarius* (E.).—Stellate, with 5, marginal, obtuse rays or teeth. 1-3120″. Fossil. Ægina.

A.? *Rota* (E.).—Wheel-like, with 10, short, obtuse, spoke-like rays. 1-1920″. Oran.

A.? *Discus* (E.).— Disciform; centre smooth; rays 8, marginal, not exserted. 1-2304″. Oran. According to Ehrenberg, the last four species may belong to Phytolitharia.

A.? *Lancearius* (E.).—Stellate, with 8 exserted, lanceolate rays, and some central shorter ones. 1-240″.

Genus DICTYOCHA (Ehr.).—Frustules free, spinous, reticulately perforated; foramina large.

* *Foramina, or cells, two or three.*

DICTYOCHA *Ponticulus*? (E.). — Frustules oblong, unarmed, transversely divided into 2 cells. 1-432″. Fossil. Bermuda.

D. *Quadratum* (E.).—Subquadrate or oblong, transversely divided into 2 cells, a spine at each end. 1-480″. Bermuda. These two forms were first observed and figured by Professor Bailey.

D. *Pons* (E.).—Roundish, with 2 cells and 4 spines. 1-504″. Oran.

D. *triacantha* (E.).—Triangular, with spinous angles; cells 3, unarmed. Maryland.

D. *tripyla* (E.). — Roundish, with 4 irregular spines; cells 3, unarmed. 1-492″. Oran.

D. *trifenestra* (E.). — Quadrate, 4-spined; cells 3, dentate. Recent and fossil. (xv. 35.)

D. *Abyssarum* (E.).—Frustules triangular, with 2 cells; spines 3; 1 cell furnished with an internal tooth. EB. 1854, p. 238. Atlantic.

2* *Diamond-shaped or quadrate; 4-spined; foramina 4 or more.*

D. *Fibula* (E.). — Cells 4, unarmed. 1-1150″ to 1-560″. Recent and fossil. (xv. 34.)

D. *Epiodon* (E.). — Resembles *D. Fibula*, but the cells are furnished with a tooth. Recent and fossil.

D. *abnormis* (E.).—Cells 5, unequal, all marginal. 1-1080″. Fossil.

D. *Crux* (E.). — Four unarmed cells round a central one. 1-624″. Fossil.

D. *Staurodon* (E.). — Resembles *D. Crux*; but each marginal cell bears a tooth. 1-576″. Fossil. Virginia.

D. *mesophthalma* (E.). — Resembles the two preceding species; but each marginal cell has 2 opposite teeth, which constrict it. 1-372". Fossil. Sicily.

D. *bipartita* (E.).—Resembles *D. Crux*, but has 2 minute cells in the centre. 1-504". Fossil. Oran and Sicily.

D. *superstructa* (E.).—Spines 4; cells 9, 4 marginal. 1-600". Fossil. Sicily.

3* *Spines* 6 (2 *usually longer*).

D. *biternaria* (E.).—Cells 6, all marginal, the 3 largest next each other. 1-432". Antarctic Ocean.

D. *Hexathyra* (E.).—Cells 6, 5 marginal and 1 central. 1-864. Fossil. Sicily.

D. *Speculum* (E.).—Six unarmed cells round a central one. Common, both recent and fossil. 1-860". (XII. 62, 63.)

D. *gracilis* (K.).—Resembles *D. Speculum*; but the spines are elongated and slender. Recent.

D. *diommata* (E.).—Six unarmed cells round 2 central ones. 1-660". Fossil. Virginia.

D. *aculeata* (E.).—Resembles *D. Speculum*; but each marginal cell bears a tooth. Common, both recent and fossil.

D. *Binoculus* (E.). — Resembles *D. aculeata*, but has 2 minute cells in the centre. 1-444". Fossil. Ægina.

D. *ubera* (E.).—Cells unarmed, 7 marginal and 2 central. 1-600". Maryland.

D. *triommata* (E.).—Cells unarmed, 6 marginal and 3 central. 1-864". Virginia.

D. *Haliomma* (E.).—Cells 10, 7 marginal and 3 central. 1-840". Oran.

D. *hemisphærica* (E.).—Hemispherical, 6-spined; 12 cells, in two circles, round a central one; the inferior aperture half closed by 6 marginal teeth. 1-744". Bermuda. *D. triommata* and *D. diommata* resemble, in their turgid habit, this species.

4* *Spines more than* 6.

D. *septenaria* (E.).—Spines 7; cells unarmed, 7 marginal and 1 central. 1-864". Oran.

D. *Ornamentum* (E.).—Resembles *D. septenaria*; but each marginal cell bears a tooth. 1-444". Fossil. Sicily.

D. *heptacanthus* (E.).—Spines 7; cells 13, 7 of them marginal. 1-552". Fossil. Greece.

D. *octonaria* (E.).—Habit of *D. Ornamentum*, with 8 spines; marginal cells irregular, fewer in number at that part where the spines are increased, and with a very large central cell. 1-1152" exclusive of spines. Perhaps a monstrous variety of *D. Ornamentum*.

D. *Stauracanthus* (E.).—Eight-spined; 4 marginal, dentate cells, round a central one. 1-648". Fossil. America.

D. *polyactis* (E.).—Rays 9 or 10; 10 marginal cells and 1 central, arranged in a reticulate stellate form. In chalk-marl.

5* *Pentagonal; angles acute, but not spinous.*

D. *elegans*.—Pentagonal, perforated by numerous small cells and 7 central large ones, of which one occupies the centre. 1-912". Fossil. Caltanisetta, Sicily.

Doubtful or obscure Species.

D. *Navicula* (E.).—Cells 8; figure oblong, obtuse, cylindrical, reticular, with a median septum like a Navicula. Fossil in chalk marl. Ehrenberg's figure resembles *D. Ponticulus*.

D.? *splendens* (E.).—Oblong, tabular, with dentate apertures (cells), 13 in number. If it be calcareous, it is similar to Coniopelta.

D. *anacantha* (E.). — Resembles *D. Speculum*, with obsolete spines. EB. 1854, p. 238. North America. Perhaps a variety.

D. *Erebi* (E.).—Resembles *D. Speculum*, with small, subequal spines; walls of the cells thin. E. *l. c.* North America. A doubtful species; perhaps a variety.

Genus MESOCENA (E.).—Frustules free, each forming a ring, which is mostly margined with spines or teeth. Mesocena resembles Dictyocha, but is destitute of its central reticulation.

MESOCENA *heptagona* (E.).—Frustules annular, with 7 external teeth. EM. pl. 20. 1. f. 49. (XII. 71.) Actiniscus?, E. Peru.

M. *octogona* (E.).—Frustules annular, with 8 external teeth. Peru. As this form differs from *M. heptagona* merely by its additional tooth, it is probably a variety.

M. *bisoctonaria* (E.).—Frustules annular, with 8 external teeth, and as many internal ones alternating with them. = *M. bioctonaria*, KA. p. 142; EM. pl. 35 A. 18. f. 10. In Peruvian guano.

M. *binonaria* (E.).—Frustules annular, with 9 external teeth, and as many internal ones alternating with them. EM. pl. 35 A. 18. f. 9. In Peruvian guano. Probably a variety of the preceding species.

M. *Circulus* (E.).—Cell circular; margin tuberculated. 1-576″. EM. pl. 19. f. 44. In Greek marl.

M. *Diodon* (E.).—In the form of a smooth elliptic ring, armed at each end with a small tooth. 1-396″. EM. pl. 33. 15. f. 18. Maryland.

M. *elliptica* (E.).—Frustules elliptic, with 4 teeth. 1-624″ to 1-456″. EM. pl. 20. 1. f. 44. Fossil. Zante.

M. *triangula* (E.).—Triangular, with rough sides, and mucronate apices. EM. pl. 22. f. 41. Fossil, chalk-marl.

M.? *Spongiolithis* (E.).—An elliptic ring, with 4 slight alternating swellings. 1-492″.

GENERA OF DOUBTFUL POSITION.

Genus EUCAMPIA (Ehr.). — Frustules hyaline, imperfectly silicious, cuneate, without terminal puncta, united into a jointed, spiral filament. Marine. This genus, placed by Ehrenberg and Kützing with the Desmidieæ, was judiciously removed by Professor Smith to the Diatomaceæ, with which it agrees in structure and in the colour of internal matter. Professor Smith, however, considered it allied to Meridion; in our opinion it is more nearly related to the Biddulphieæ, as shown by the absence of costæ and terminal puncta, its dotted valves, and their prominence in the front view.

EUCAMPIA *Zodiacus* (E.).—Frustules, in front view, with the junction-margins deeply sinuated, so as to form foramina between the joints. E. Leb. Kreidethierchen, pl. 4. f. 8; SD. ii. p. 25, pl. 60. f. 299. Europe. (II. 43.)

E. *Britannica* (S.).—Frustules cuneate, not excavated. SD. ii. p. 25, pl. 61. f. 378. Europe. Stomach of Pectens.

Genus LITHODESMIUM (Ehr.).—Frustules not cellulose, united into a jointed, prismatic wand; valve triangular, with one side plane, and the others undulated. Lithodesmium was placed with the Desmidieæ by Ehrenberg, and with the Diatomaceæ by Kützing. Its non-cellulose structure, however, prevents our associating it with the Anguliferæ, as proposed by the latter.

LITHODESMIUM *undulatum* (E.). — Frustules smooth, very pellucid; valves with obtuse angles. E. Leb. Kreidethierchen, 1840, p. 75, pl. 4. f. 13. Marine. Cuxhaven. (II. 41, 42.)

Genus MICROTHECA (Ehr.).—Frustules simple, free, compressed, quadrate. Placed by Ehrenberg and Kützing with the Desmidieæ. We remove it to the Diatomaceæ, because of its marine habitat and golden colour; little, however, is known about it, and its nature is doubtful.

MICROTHECA *octoceras* (E.). — Cell quadrate, hyaline, with four spines at each end; internal matter of a golden colour. E Inf. p. 164, pl. 12. f. 10. Marine. Kiel. (VIII. 31.)

ADDENDA TO THE DIATOMACEÆ.

CYCLOTELLA *pertenuis* (B.).—Valves minute, slightly convex; surface minutely cellulate or punctate; cells radiant. B. on Mic. Forms in the Sea of Kamtschatka.

The following corrections and addition to CYCLOTELLA are adopted from Professor Arnott's paper in JMS. viii. p. 244.

For C. *operculata* (p. 811), substitute:—

C. *operculata* (Ag., Kutz.). — Ends of frustules undulate; valves with smooth centre, and close, short marginal striæ. KB. p. 50, pl. 1. f. 1. = *Frustulia* and *Cymbella operculata*, Ag.; *Pyxidicula operculata*, E. Fresh water. Europe.

[Professor Arnott regards *Stephanopyxis Niagaræ*, and perhaps *S. Egyptiacus*, as identical with *C. Astræa*.]

For C. *rectangula* (p. 811), substitute:—

C. *Meneghiniana* (K.). — Front view rectangular; valves minute, with smooth centre and rather coarse marginal striæ. KB. p. 50, pl. 30. f. 68. *C. rectangula*, Rab D. p. 11. Europe. Fresh water.

For C. *Dallasiana* (p. 813), substitute:—

C. *Dallasiana* (Sm.).—Frustules with flat ends; valves with bullate-rugose centre and coarse marginal striæ. SD. ii. p. 87. = *C. radiata*, Bri. TMS. viii. pl. 6. f. 11. Brackish water. Europe, America.

C. *minutula* (K.). — Frustules with flat ends; valves with radiating dots or striæ at centre. KB. pl. 2. f. 3. = *C. operculata*, SD. i. p. 28, pl. 5. f. 48. Europe. (Kützing, however, describes his *C. minutula* as undulate.)

C. *Kützingiana* (Th.). — Ends of frustules undulate; valves with convex, smooth centre, and long, coarse marginal striæ. SD. i. p. 27, pl. 5. f. 47. Brackish water. Europe.

Cocconeis *Finnica*. — On careful examination of several fossil deposits said by Ehrenberg to contain this species, we can find no form resembling the figures in the 'Microgeologie,' excepting *Navicula elliptica*.

Eupodiscus? *Peruvianus* (Kitton, MS.). — Valve orbicular, finely punctated, with two small, roundish submarginal processes, and a submarginal series of close minute apiculi. Peruvian and Californian guanos. We regard the genus of this Diatom as doubtful. The valve has some resemblance to an Auliscus; but the puncta are not in flexuose lines. The processes, as seen in front view, are short and subtruncate, and the circle of apiculi which connects them shows an affinity to Cerataulus. The processes of the one valve alternate with those of the other, and are often visible at the same time.

E.? *Grevillii* (Ralfs, n. sp.).—Disc obscurely punctate, with (3) clavate intramarginal processes, and a circlet of spines between the processes and the centre. Monterey. Dr. Greville. The processes, which are rather distant from the margin, resemble those of Aulacodiscus, and the circlet of spines that of Systephania; but the absence of connecting lines removes it from the former, and the presence of processes from the latter genus.

Podosira? *compressa* (West).—Frustule geminate, free?; polar always shorter than equatorial diameter; valves elliptic, obscurely punctate; puncta scattered; angulum smooth. Creswell Sands, Druridge Bay, Yarmouth Sands. West, TMS. viii. p. 150, pl. 7. f. 11. (viii. 34.) This form occurs plentifully on the sands; the frustules always occur in pairs. The absence of stipes or any attachment, the compressed valves, and the want of a thickened umbilicus, render its position in the present genus doubtful.

Epithemia (*Eunotia*, E.) *Sancti Antonii* = *E. Beatorum* = *Denticula*? *lauta* (Bail.). — This species has been found by Mr. Kitton in the Monterey-stone and Richmond deposits; in the latter they occur in filaments of 6 and 7 frustules, clearly showing that they are improperly placed in the present genus, and are probably allied to Denticula.

Navicula *bullata* (Norman, n. sp.).—"Elliptical, extremities slightly produced; striæ in a marginal and two central bands; marginal band of unequal width; the blank spaces between the granules studded with a line of circular bosses; striæ moniliform, 14 in 001". Stomachs of Ascidians, Shark Bay, Australia" (Norman *in litt.*).

N. *Sillimanorum* (E.).—Inflated at the centre; apices produced, rounded, and constricted; striæ radiant, not reaching the median line. EM. pl. 2. 2. f. 13. = *Pinnularia Sillimanorum*, EA. p. 133. New York deposit. This species resembles *Gomphonema geminatum*, but is distinguished by its less conspicuous striæ and equal ends; the figure in EM. represents only a fragment.

N. *Cyprinus* (E., K.).—Small; valves oblong, slightly contracted into the very broad obtuse ends; central nodule oblong; striæ evident. KB. p. 99, pl. 29. f. 35. = *Pinnularia Cyprinus*, EA. pl. 1. 11. f. 7. Chili.

N. *Reinickeana* (Rab.). — Resembles *N. cuspidata* and *N. rostrata*; but the capitate ends are more prolonged, and the striæ are only 30 in ·001". Rab. Algen Sachs. No. 802. Dresden.

Aulacodiscus *Sollittianus* (Norman, MS.).—"Disc large, hyaline, with six conspicuous processes, distant from margin; granules radiating, not reaching the centre, 9 in ·001″; smooth round the base of the processes. Deposit from Nottingham, below Maryland, which seems to be identical with the Bermuda tripoli, and contains several forms peculiar to that deposit" (Norman *in litt.*).

A. *Barbadensis* (Ralfs, n.s.). — Disc large, hyaline, very minutely punctated, with small umbilicus, (3) intramarginal roundish processes, and faint connecting lines. Barbadoes deposit. Distinguished by its very obscure puncta. The rather large processes, when nearly out of focus, appear to have a central dot.

Triceratium *crenatum* (Kitton, *MS.*). —Sides rounded, margin crenate; granules radiating from the pseudo-nodule, distinct at the margin, but less conspicuous as they approach the centre. = *Discoplea undulata*, EM. pl. 33. 18. f. 3. Nottingham deposit. The presence of the pseudo-nodule shows it to be an ally of *T. Brightwellii*; but the nearly orbicular outline and crenate margin distinguish it from that species. The fragment figured by Ehrenberg we have no doubt is identical with this form.

T. *Bowerbankiana* (Ralfs). — Valves with two concentric circles, radiating lines between the circles, distinctly punctated angles, and blank or indistinctly punctated centre. Barbadoes deposit. The large valve has nearly straight sides, and obtuse angles; it is divided into three parts by two suture-like circles, the outer one with a border of bead-like dots, which are most evident nearest the sides; the lines between the circles are abbreviated, only one on each side reaching the inner circle.

Craspedodiscus *Barbadensis* (Ralfs, n. s.).—Border very broad, its diameter greater than that of the centre; cellules of centre very minute, those of border larger and arranged in curved, decussating lines. Barbadoes deposit. Disc about the size of *C. Coscinodiscus*, but with a much smaller centre. It differs from both that species and *C. microdiscus* in having the cellules of the border in curved series.

Substitute the following descriptions for the notices of Craspedodiscus *Stella* and C. *Franklini* at p. 832:—

C.? *Stella* (E.).—Valves hemispherical, with a very broad, smooth, obsoletely radiated limb, and a small, finely cellulose centre, having an irregular margin; rays 12, irregular. EB. 1855, p. 238; E M. pl. 35 b. b. 4. f. 11. North America. On account of its rays, this form may be the type of a new genus; but they were distinct only in a single specimen, whilst in the greater number scarcely a trace of them could be detected. It approaches to the characters of Symbolophora.

C. *Franklini* (E.).—Disc turgid, with a deciduous, broad, hyaline, smooth marginal limb, and a very fine punctated (yellowish) centre, having an irregular margin; centre and limb of nearly the same diameter. ERBA. 1853, p. 526; EM. pl. 35 a. 23. f. 6. Assistance Bay. Akin to *Coscinodiscus disciger*.

To C. *semiplanus* (Bri.), add:—

This Diatom, which is not uncommon in the Barbadoes deposit, is no doubt incorrectly placed in this genus. In our opinion it is closely allied to Asterolampra, and should either be united to that genus, or a new genus formed to include this and other allied discs associated together in the deposit. Mr. Brightwell's specimen must have been imperfect, since we find the radiating lines invariably correspond in number with the marginal compartments.

To C. *marginatus* (Bri.), add:—

We consider that this Diatom also is wrongly referred to Craspedodiscus, and, notwithstanding its large punctated centre, is really more allied to Asterolampra,—its marginal compartments, however, being extremely minute. In the Barbadoes deposit we find discs sometimes (as in Asterolampra) without any umbilical cellules, and sometimes with a large cellulose centre, and these extremes so connected by intermediate states as to make it doubtful whether the cellulose centre is available even as a specific distinction. We hope Dr. Greville, who has paid much attention to these forms, will soon publish a monograph of them in continuation of his former admirable paper on Asterolampra.

For CRASPEDODISCUS *coronatus*, substitute the following :—

Genus BRIGHTWELLIA (Ralfs, n. g.).—Disc with a large granulated centre, separated from a broad punctated limb by a circlet of oblong cellules.

We have constituted this genus to receive a beautiful Diatom placed by Mr. Brightwell in Craspedodiscus, but which differs so greatly from other Diatoms that we believe it should form the type of a new one, which, with much pleasure, we dedicate to the author of the excellent monographs of Triceratium and the Chætocereæ.

BRIGHTWELLIA *coronata* (Bri., Ralfs). — Central portion of valve with an irregular blank umbilicus and radiating series of granules, which are closer and in curved lines near the circlet of cellules. = *Craspedodiscus coronatus*, Bri JMS. viii. p. 95, pl. 5. f. 6. Barbadoes deposit. This species is very variable in size. In a dry state it is of a purplish or brown colour, but in balsam hyaline; the centre has the granules irregular near the umbilicus, and interrupted by blank rays; but near the circlet of cellules they become more regular, and form curved, moniliform lines. The broad limb is usually brownish when dry, and marked by numerous radiating lines, similar to those of *Coscinodiscus concinnus*, and have in the intervals extremely minute obliquely arranged granules. The radiating lines, although conspicuous in the dry state, nearly disappear in balsam.

After CYMATOPLEURA *Ovum* (p. 793), insert :—

C. *multifasciata* (Kütz.). — Valves linear, with acutely cuneate apices, and very fine transverse striæ. = *Surirella multifasciata*, KB. p. 60, pl. 3. f. 47. Europe.

C. *thermalis* (Kütz.). — Slightly panduriform, otherwise as in *C. multifasciata*. = *Surirella thermalis*, KB. p. 60, pl. 3. f. 46. Europe.

Genus CYLINDROTHECA (Rab.).—Frustules exactly cylindrical, with percurrent spires, and imbedded in an amorphous, gelatinous mucus.

CYLINDROTHECA *Gerstenbergeri* (Rab.). —Frustules lanceolate, acute, with two (rarely one or three) spires. Rab. Algen Sachsens, No. 801. Dresden.

Note.—Mr. Ralfs originally proposed to introduce a family Synedreæ, as mentioned in p. 758, but subsequently transferred the genera to the family Surirelleæ, the genera in which he distributes thus :—

* *Frustules bacillar ; valves keeled*—NITZSCHIEÆ.

Genera. Nitzschia, Ceratoneis, Amphipleura, Bacillaria, and Homœocladia.

2* *Frustules bacillar ; valves scarcely broader than front view, not keeled*—SYNEDREÆ.

Genera. Synedra, Desmogonium, Dimeregramma, and Staurosira.

3* *Frustules not bacillar ; valves mostly broader than front view, not keeled*—SURIRELLEÆ.

Genera. Rhaphoneis, Tryblionella, Cymatopleura, Surirella, Campylodiscus, and Calodiscus.

INDEX

TO

THE FIGURES ILLUSTRATING THE DIATOMACEÆ.

DESCRIPTION OF THE ENGRAVINGS.

PLATE I. (Desmids).

Figures 1 to 14. Cosmarium margaritiferum, &c., under different stages of development: **1, 2.** Frond, enclosing "vesicles" filled with moving granules; **3.** Supposed early state of moving granules; **4.** Early stage of self-fission; **5.** Fission-products escaping the enclosing wall of parent cell; **6.** Separation completed; **7.** Sporangium still connected with parent frond; **8.** Same with mammilliform spines; **9.** Sporangium further developed; **10, 11.** Supposed mature sporangia; **12.** Same, broken and empty; **13, 14.** Young supposed products of sporangial contents: all after Mrs. Thomas, TM. 1855. [We are disposed to think that one or two other species besides Cosmarium margaritiferum are here confounded. 4, we suggest, may possibly be C. cælatum or C. cristatum, showing nascent segments; 7, C. Broomei, the empty frond to the right showing a segment not yet fully developed; 8 and 9 appear to us as probably more likely to represent the conjugated state and sporangium of C. bioculatum, of which figs. 10, 11, 12, may represent the ultimately extruded inner membrane, while figs. 13 and 14 may truly be the young fronds developed from their contents, and which have not yet commenced vegetative self-division.] **15–17.** Sphærozosma vertebratum (Ralfs): **15.** A portion of a filament seen in f. v. ×200; **16.** tr. v. ×400; **17.** s. v. ×400. **18, 19.** Micrasterias papillifera (Bréb.): **18.** f. v. ×100; **19.** Sporangium ×200. **20.** M. rotata (Ralfs), f. v. ×100. **21.** M. radiosa (Ag.), f. v. ×100. **22.** M. Crux-Melitensis (Ralfs), f. v. ×100. **23–25.** Euastrum Didelta (Ralfs): **23.** f. v. with endochrome; **24.** e. f. in f. v.; **25.** tr. v.: all ×200. **26.** E. rostratum (Ralfs), f. v. ×400. **27, 28.** Xanthidium armatum (Bréb.): **27.** f. v.; **28.** s. v.: both ×200. **29, 30.** Arthrodesmus octocornis (Ehr.): **29.** var. β, f. v.; **30.** var. α, f. v.: both ×400. **31–34.** Staurastrum cuspidatum (Bréb.): **31.** f. v.; **32.** showing the nascent segments; **33.** tr. v.; **34.** e. v.: all ×400. **35, 36.** Ankistrodesmus falcatus (Ralfs), ×400. **37–39.** Scenedesmus obtusus (Meyen), after Nägeli, showing segmentation of the cell-contents, ×300. **40–42.** S. caudatus, after Nägeli, ×300. **43.** Same, segmentation of cell-contents, ×400. **44, 45.** A few marginal cells of "Pediastrum Selenæa (Kg.)" = P. pertusum (?), after Nägeli, ×300. **46–48.** P. (Anomopedium) integrum (Näg.): **46.** ×150; **47.** ×400; **48.** s. v. ×400. **49–51.** Cœlastrum sphæricum (Näg.): **49.** ×200; **50, 51.** ×300. **52.** Pediastrum Ehrenbergii (Braun), after Braun, ×400. **53.** P. Selenæa (Kg.) [non Ralfs, = P. pertusum], after Nägeli, ×150. **54, 55.** Cœlastrum cubicum (Näg.), after Nägeli, ×300. **56–58.** Sorastrum spinulosum (Näg.): **56.** ×300; **57, 58.** ×600. **59–61.** Pediastrum Boryanum, var. brevicornis, after Braun: **59.** Two marginal cells, one empty, the other discharging the original inner membrane closely investing the microgonidia; **60.** The same half an hour afterwards, considerably dilated, the microgonidia each with a pointed hyaline beak, and at first slowly moving; **61.** Microgonidia, eventually emitted, swimming freely: all ×300. **62.** P. granulatum (Kg.). **63.** Brood of macrogonidia emerged from shell of old frond, ×400. **64.** A few marginal cells of an old frond, some empty, the cell-contents of others undergoing previous segmentation, and one discharging the inner membrane investing the brood of macrogonidia (Braun), ×400. **65.** Same as **63**, seen from the edge, ×400. **66.** Same, seen in f. v., the cells now slightly emarginate, ×400. **67.** Same, four hours after the macrogonidia have ceased to move, the marginal cells now drawn out into horns, but not yet having assumed their proper form, and all exhibiting spaces between, not yet having become closely applied to each other, ×400. **68, 69.** P. Boryanum: microgonidia treated with tincture of iodine and sulphuric acid, showing the vibratile cilia, the slightly retracted contents, and a nucleus, ×500. (Figs. 63–69 after Braun.)

PLATE II. (Desmids).

Figures 1 & 5. Closterium Leibleinii (Kg.), ×200: **1.** A frond filled with endochrome, and an empty one lying across it (the latter shows the central suture); **5.** Sporangium lying between the conjugated, and now empty fronds. **2 & 6.** Closterium striolatum (Ehr.), ×100: **2.** A frond with endochrome, showing the longitudinal fillets and the single row of large granules; **6.** Two empty conjugated fronds, showing the striæ and the orbicular sporangium lying between them, enveloped in mucus. **3.** Staurastrum (Desmidium, Ehr.) eustephanum, e. v. **4.** Spirotænia condensata (Bréb.), ×200: the frond is seen with its spiral band of endochrome, and surrounded by a mucous hyaline sheath. **7.** Staurastrum (Desmidium, E.) senarium. **8 & 11.** Docidium Ehrenbergii (Ralfs), ×100: **8.** Conjugating fronds, the sporangium in an early stage of development; **11** shows the process of development by fission, the young segments partially grown. **9.** Docidium clavatum (Kg.), ×100. **10 & 30.** Euastrum pectinatum (Bréb.), ×200: **10.** A single frond; **30.** The spinous sporangium, the empty segments adjacent. **12, 13.** Tetmemorus Brebissonii (Ralfs), ×200: **12.** f. v.; **13.** s. v. **14, 15.** Penium margaritaceum (Bréb.), ×200: **14.** f. v. var. *a*; **15.** s. v. of two empty fronds, var. γ, the sporangium between them. **16, 17.** Staurastrum alternans (Bréb.), ×400: **16.** f. v.; **17.** e. v. **18 & 23.** Xanthidium cristatum (Bréb.), ×400: **18.** f. v.; **23.** e. v. **19 & 36.** Scenodesmus quadricauda (Ralfs), ×400: **19.** A frond of two cells; **36.** one of four cells. **20, 21, 24, 25 & 31.** Staurastrum polymorphum (Bréb.), ×400; **20.** e. v. (of five-rayed var.); **21 & 31.** f. v.; **24.** A frond multiplying by self-division; **25.** Sporangium with its furcate spines, and around it the empty and previously conjugated fronds. **22.** Micrasterias denticulata (Bréb.), ×100, sporangium of. **26.** Cosmarium cælatum (Ralfs), ×300: front view of frond multiplying by self-division, the young segments partially grown and their surface still smooth. **27.** Pediastrum tetras (Ralfs), ×400, f. v. of a frond. **28, 29.** Tetrachastrum oscitans (Dixon), ×100: **28.** f. v.; **29.** tr. v. of e. f. **32 & 35.** Hyalotheca dissiliens (Bréb.): **32.** ×200, tr. v. with investing hyaline gelatinous sheath; **35.** ×400, f. v., also showing the sheath. **33, 34.** Cosmarium undulatum (Corda), ×400: **33.** f. v.; **34.** Sporangium with the empty fronds. **37 & 40.** Desmidium quadrangulatum (Ralfs): **37.** ×200, f. v. of filament; **40.** ×300, tr. v. **38, 39.** Didymoprium Borreri (Ralfs), ×400: **38.** tr. v.; **39.** Portion of a filament, f. v. Diatoms:—**41, 42.** Lithodesmium undulatum; **43.** Eucampia Zodiacus. Desmid:—**44.** Micrasterias Americana. Diatoms:—**45.** Podosira moniliformis attached to Polysiphonia; **46, 47, 49, 50.** Biddulphia pulchella; **48.** Denticella Biddulphia.

PLATE III. (Desmids).

Figure 1. Gonatozygon Ralfsii (De Bary), three joints of, ×300; **2.** Same, conjugated, showing *sporangium*, ×300. **3.** Genicularia spirotænia (De Bary), single joint of, ×150 (vide De Bary, op. cit. iv. 1. p. 717), ×300. **4.** Leptocystinema Kinahani (Archer), ×200, showing front and side views of the band of endochrome, and two joints with nascent halves. **5.** Aptogonum Baileyi (Ralfs), ×400; **6.** Same, e. v. **7.** Desmidium Aptogonum (Bréb.), portion of a filament, ×400; **8.** Same, e. v. ×400. **9.** Spondylosium depressum (Bréb.), ×300: five joints, one dividing. **10.** S. pulchellum (Archer), ×450: five joints of a filament. **11.** Euastrum oblongum (Ralfs), ×200. **12.** E. insigne (Hass.), ×200. **13.** E. binale (Ralfs), × 400. **14.** Cosmarium pyramidatum (Bréb.), × 300; **15.** Same, e. v. ×300. **16.** C. cylindricum (Ralfs), ×300; **17.** Same, e. v. ×300. **18.** Staurastrum avicula (Bréb.), × 300; **19.** Same, e. v. ×300. **20.** S. teliferum (Ralfs), ×300; **21.** Same, e. v. ×300. **22.** S. spongiosum (Bréb.), ×300; **23.** Same, e. v. ×300. **24.** S. quadrangulare (Bréb.), ×300; **25.** Same, e. v. **26.** S. globulatum (Bréb.); **27.** Same, e. v. **28.** S. gracile (Ralfs), ×300; **29.** Same, e. v. ×300. **30.** S. vestitum (Ralfs), ×300; **31.** Same, tr. v. ×300. **32.** S. furcigerum (Bréb.), ×200; **33.** Same, e. v. ×200. **34.** S. margaritaceum (Menegh.), × 300; **35.** Same, e. v. × 300. **36.** Arthrodesmus Incus (Hass.), × 400. **37.** Triploceras verticillatum (Bailey). **38.** Docidium Baculum (Bréb.), ×200. **39.** Closterium didymotocum (Corda), ×100. **40.** C. turgidum (Ehr.), × 100. **41.** C. lineatum (Ehr.), × 100; **42.** Same, conjugated, showing the double sporangium, ×100. **43.** C. attenuatum (Ehr.), ×100. **44.** C. rostratum (Ehr.), ×100. **45.** Penium interruptum (Bréb.), ×200. **46.** Docidium Ehrenbergii (Ralfs), ×200, after W. Archer (Nat. Hist. Review, vii. p. 375): commencement of growth of lateral tube preparatory to the formation of zoospores. **47.** Same, the zoospores emitted and forming an external cluster (p. 716). **48–54.** After De Bary (op. cit.); all ×190, showing development of sporangium of Cosmarium Botrytis (Menegh.): **48.** The inner membrane with contents escaping by bursting the outer wall of the sporangium; **49.** The same escaped, somewhat further developed, preparatory to segmentation of the contents, the external membrane doubled; **50.** The same, division finished; **51.** The same, 1½ hour after; **52.** The same, at a later stage; **53.** Germ-cells, ordinary vegetative division begun; **54.** Product of the first division of a germ-cell, each new half (but not until now) having assumed the characteristic form of the species. **55–60.** After De Bary (op. cit.), all ×390, showing development of sporangium of Cosmarium Meneghinii (Bréb.): **55.** Empty outside coat of a sporangium with an open slit or fissure by which the inner membrane (with contents) has come out; **56.** The emerged inner membrane and contents; **57.** A pair of germ-cells formed therein; **58.** The same, one escaping; **59, 60.** Products of the germ-

cells, showing one segment the form of the germ-cell, the other, ordinary vegetative division supervening, having assumed that characteristic of the species. **61.** Euastrum didelta (Ralfs), ×150, abnormal condition of, after W. Archer (Nat. Hist. Review, vi. p. 469), showing a central irregular structure produced between the original segments, apparently owing to the non-formation of a septum on the resumption of vegetative growth, and forming with them but one uninterrupted cavity; and in this instance the new central growth having assumed the size and nearly the form of an entire frond, its axis of growth and plane of expansion are at right angles to the old segments. **62.** Arthrodesmus Incus (Hass.), ×300, abnormal condition of, after W. Archer, *l. c.*, showing an abnormal growth analogous to preceding, but carried on to another vegetative generation, the middle portion being older than those produced between it and the original segments, the whole still forming within but one uninterrupted cavity. **63.** Cosmocladium pulchellum (Bréb.), ×250.

PLATE IV. (Diatoms).

[Plates IV. to VIII. are engraved by Mr. Tuffen West. Many of the figures are from original drawings, others from specimens, and all of them are magnified 300 diameters.]

Figure 1. Epithemia turgida, f. and s. v. **2.** E. Westermanni. **3.** Eunotia pentaglyphis. **4.** E. triodon. **5.** Amphicampa mirabilis. **6.** Himantidium pectinale, f. and s. v. **7.** Podosphenia Ehrenbergii, f. and s. v. **8.** Rhipidophora paradoxa. **9.** Licmophora flabellata. **10.** Podocystis Adriatica. **11.** Sceptroneis Caduceus. **12.** Dimeregramma sinuatum, f. and s. v. **13.** Diatoma vulgare, f. and s. v. **14.** D. elongatum. **15.** D. Ehrenbergii. **16.** D. hyalinum, f. and s. v. **17.** Asterionella formosa. **18.** A. Ralfsii. **19.** Bacillaria paradoxa, f. and s. v. **20.** B. cursoria. **21.** Nitzschia Sigma. **22.** N. scalaris, f. and s. v. **23.** Ceratoneis longissima, f. and s. v. **24.** Homœocladia Martiana, f. and s. v. **25.** H. filiformis. **26.** H. sigmoidea. **27.** Synedra Arcus, f. and s. v. **28.** S. pulchella, f. and s. v. **29.** S. capitata. **30.** Amphipleura pellucida. **31.** A. inflexa. **32.** Plagiogramma pulchellum, f. and s. v. **33.** Dimeregramma nanum, f. and s. v. **34.** D. distans, f. and s. v. **35.** D. Tabellaria, f. and s. v. **36.** Tryblionella gracilis. **37.** T. acuminata. **38.** Campylodiscus Hibernicus. **39.** C. spiralis. **40.** Striatella unipunctata, f. and s. v. **41.** Rhabdonema minutum, f. and s. v. **42.** Hyalosira delicatula, f. and s. v. **43.** Rhabdonema Crozieri, f. and s. v. **44.** Biblarium Castellum (EM. 33. 2. 1.). **45.** Stylobiblium Clypeus. **46.** Gomphogramma rupestre, f. and s. v. **47.** Grammatophora marina. **48.** G. serpentina, f. and s. v. **49.** Gephyria media, f. and s. v. upper and under valves. **50.** G. incurvata, f. and s. v. ditto. **51.** Diatomella Balfouriana, f. and s. v. **52.** Disiphonia australis.

PLATE V. (Diatoms).

Figure 53. Cyclotella operculata, f. and s. v. **54.** C. rectangula, f. and s. v. **55.** Actinogonium septenarium. **56.** Liostephania magnifica. **57.** L. Rotula. **58.** Dictyolampra Stella. **59.** Mastogonia Actinoptychus. **60.** Hyalodiscus subtilis. **61.** Podosira Montagnei, f. and s. v. **62.** Melosira Horologium, f. and s. v. (EM. 33. 2. 17). **63.** M. subflexilis, f. and s. v. **64.** M. nummuloides, f. and s. v. **65.** M. orichalcea. **66.** Asteromphalus Arachne. **67.** Melosira Roseana, f. and s. v. **68.** Discosira sulcata, f. and s. v. **69.** Stephanodiscus Ægyptiacus, f. and s. v. **70.** Endictya oceanica, f. and s. v. **71.** Melosira Borreri, f. and s. v. **72.** Liparogyra spiralis, f. and s. v. **73.** Peristephania Eutycha. **74.** Stephanopyxis Turris. **75.** S. ferox, f. and s. v. **76.** Xanthiopyxis oblonga. **77.** Stephanogonia polygona, f. and s. v. **78.** Coscinodiscus ovalis. **79.** Asteromphalus Brookei. **80.** Craspedodiscus Coscinodiscus. **81.** Systephania Corona. **82.** Halionyx undenarius. **83.** Coscinodiscus stellaris. **84.** Actinocyclus Ralfsii. **85.** Heterostephania Rothii. **86.** Asteromphalus Darwinii. **87.** A. elegans. **88.** Actinoptychus undulatus, f. and s. v. **89.** Coscinodiscus concinnus. **90.** Odontodiscus eccentricus.

PLATE VI. (Diatoms).

Figure 1. Auliscus pruinosus. **2.** Eupodiscus Argus: *a*, s. v.; *b*, f. v. (the latter from Kützing). **3.** Auliscus sculptus: *a*, s. v.; *b*, f. v. **4.** Aulacodiscus Oreganus. **5.** A. Beeveriæ. **6.** Porpeia quadriceps: *a*, s. v.; *b*, f. v. **7.** Cerataulus lævis: *a*, s. v.; *b*, filament. **8.** Hydrosera compressa, s. v. **9.** Cerataulus turgidus: *a*, s. v.; *b*, f. v. **10.** Biddulphia Tuomeyi: *a*, s. v.; *b*, f. v. **11.** Zygoceros Mobiliensis: *a*, s. v.; *b*, f. v. **12.** Biddulphia Indica. **13.** Hydrosera triquetra: *a*, s. v.; *b*, filament. **14.** Hemidiscus cuneiformis: *a*, s. v.; *b*, f. v. **15.** Triceratium Solenoceros. **16.** T. exiguum. **17.** T.

venosum. **18.** T. contortum. **19.** T. spinosum. **20.** T. punctatum. **21.** T. alternans: *a*, s. v.; *b*, f. v. **22.** Amphipentas flexuosus: *a*, with five angles; *b*, var. with four angles. **23.** Pleurodesmium Brébissonii: *a*, s. v.; *b*, f. v. **24.** Chætoceros Wighamii: *a*, Goniothecium-like frustule, f. v.; *b*, same, s. v.; *c*, s. v. of connecting zone and awns without the frustule; *d*, filament entire. **25.** C. boreale: *a*, s. v.; *b*, f. v. **26.** Bacteriastrum furcatum. **27.** B. Wallichii: *a*, s. v.; *b*, filament (This figure is introduced for the sake of the f. v., which so closely resembles Bacteriastrum furcatum and B. curvatum as to be undistinguishable in this aspect). **28.** Dicladia Capreolus: *a*, s. v.; *b*, f. v. **29.** Goniothecium Odontella: *a*, s. v.; *b*, f. v. **30.** Periptera tetracladia.

PLATE VII. (Diatoms).

Figure 31. Rhizosolenia Calyptra. **32.** R. styliformis, from a figure sent by G. Norman, Esq., Hull. **33.** R. setigera. **34.** Syringidium Americanum. **35.** Hercotheca mammillaris. **36.** Cocconeis Placentula. **37.** C. transversalis. **38.** C. distans. **39.** C. pseudomarginata. **40.** C. excentrica. **41.** Achnanthidium coarctatum. **42.** Achnanthes longipes. **43.** A. subsessilis. **44.** A. exilis. **45.** Cymbella cuspidata. **46.** C. Ehrenbergii. **47.** Cocconema parvum: *a*, s. v.; *b*, f. v. **48.** C. Boeckii: *a*, s. v.; *b*, f. v. **49.** Encyonema prostratum (frustules): *a*, s. v.; *b*, f. v. **50.** Amphora angularis. **51.** A. membranacea. **52.** A. litoralis. **53.** Syncyclia Salpa. **54.** Amphora cymbifera: *a*, upper surface in focus; *b*, lower surface in ditto. **55.** Navicula tumida: *a*, s. v.; *b*, f. v. **56.** Amphora ovalis. **57.** A. spectabilis: *a*, upper surface in focus; *b*, lower surface in ditto. **58.** A. hyalina. **59.** A. marina. **60.** Gomphonema geminatum. **61.** Navicula didyma. **62.** N. Hitchcockii. **63.** Stauroneis obliqua. **64.** S. Crucicula. **65.** Navicula (Pinnularia) major. **66.** N. producta. **67.** Stauroneis linearis. **68.** Navicula rhynchocephala. **69.** N. Hennedyi. **70.** N. latissima. **71.** N. rhombica. **72.** N. Amphisbæna: *a*, s. v.; *b*, f. v. **73.** N. Cluthensis. **74.** N. borealis. **75.** N. maxima. **76.** Stauroneis acuta. **77.** S. pulchella.

PLATE VIII. (Diatoms).

Figure 1. Oncosphenia? (Diatoma elongatum γ, SBD.). **2.** Eupleuria ocellata. **3.** Synedra robusta **4.** Dimeregramma pinnatum. **5.** Tessella interrupta. **6.** Dimeregramma Harrisonii. **7.** Nitzschia Brightwellii. **8.** Eupleuria pulchella. **9.** Achnanthidium trinode. **10.** Tetracyclus lacustris, s. v. **11.** Cladogramma Californicum. **12.** Rhabdonema mirificum, f. v. and s. v. **13.** Cyclotella punctata. **14.** Asteromphalus centraster, punctations of compartments omitted. **15.** Omphalopelta areolata. **16.** Amphitetras ornata. **17.** Melosira arenaria, s. v. **18.** Coscinodiscus nitidus. **19.** Perithyra denaria. **20.** Syringidium bicorne. **21.** Asteromphalus heptactis. **22.** Euodia gibba. **23.** Biddulphia Macdonaldii. **24.** Aulacodiscus Kittoni. **25.** Periptera chlamidophora. **26.** Coscinodiscus excavatus. **27.** Triceratium trisulcum. **28.** Aulacodiscus pulcher. **29.** Triceratium castellatum. **30.** Eunotogramma, s. v. **31.** Microtheca octoceras. **32.** Pleurosigma formosum. **33.** P. Balticum. **34.** Podosira? compressa. **35.** Attheya decora. **36.** Staurogramma Persicum. **37.** Anaulus scalaris. **38.** Schizonema Grevillii. **39.** Lysicyclia Vogelii. **40.** Schizonema Dillwynii. **41.** Rhizonotia Melo? **42.** Rhizosolenia robusta. **43.** Colletonema eximium. **44.** Omphalotheca hispida. **45.** Pleurosiphonia affinis. **46.** Toxonidea undulata. **47.** Colletonema neglectum. **48.** Stigmaphora rostrata. **49.** Donkinia carinata, s. v. **50.** Calodiscus superbus.

PLATE IX. (Diatoms).

Figure 131. Melosira sulcata. ***131.** M. varians. **132.** Actinoptychus senarius. **133–136.** Navicula viridis. **137, 138.** Surirella striatula. **139.** Stauroneis Phœnicenteron. **140.** Amphipleura pellucida. **141.** Navicula Amphisbæna. **142.** Stauroneis platystoma. **143.** Navicula nodosa. **144.** Pleurosigma Balticum. **145.** P. hippocampus. **146.** P. acuminatum. **147.** Synedra subtilis. **148.** Nitzschia sigmoidea. **149.** Cymatopleura elliptica. **150–152.** Surirella splendida. **153.** Amphora ovalis. **154.** Cymbella Ehrenbergii. **155.** Cymatopleura Solea. **156–161.** Epithemia turgida (except, in group 157, those figures marked with a cross). ***157.** Epithemia Westermanni. **162, 163.** Cocconeis scutellum. **164.** Eunotia triodon. **165.** Epithemia granulata. **166, 167.** Bacillaria paradoxa. **168.** Diatoma vulgare. **169.** D. elongatum. **170.** D. mesodon. **171.** Himantidium pectinale. **172.** Odontidium hyemale. **173–175.** Fragilaria capucina. **176.** F. virescens. **177–179.** Meridion circulare. **180–182.** Rhabdonema arcuatum.

PLATE X. (Diatoms and Protozoa).

Figure 183. Isthmia enervis. **184.** Synedra Ulna. ***185.** S. capitata. **185.** S. lunaris. **186.** Podosphenia gracilis. **187–190.** Gomphonema constrictum. **191–193.** Licmophora flabellata. **194, 195.** Cocconema lanceolatum. **196–198.** C. Cistula. **199–202.** Achnanthes brevipes. **203, 204.** Rhabdonema arcuatum. **205.** Acineta mystacina. **206.** Syncyclia Salpa. **207.** Schizonema Hoffmannii. **208.** Micromega Agardhii. Protozoa:—**209–211.** Cyclidium Glaucoma. **212.** Pantotrichum Enchelys. **213.** Chætomonas Globulus. **214, 215.** Chætotyphla armata. **216–218.** Chætoglena volvocina. **219, 220.** Peridinium Tripos. **221.** P. Michaelis. **222, 223.** Peridinium Fusus. **224–226.** Glenodinium apiculatum. **227.** Trichodina tentaculata. **228–230.** T. Pediculus. **231, 232.** Urocentrum Turbo. **233, 234.** Stentor Rœselii.

PLATE XI. (Diatoms).

Figures 1 to 8. Epithemia turgida (Thwaites): **1.** A view of concave surface; **2.** A side view; **3.** Apposition of concave surfaces in the first stage of conjugation; **4.** A front view of a single endochrome, showing it to have divided into two segments; **5.** The young sporangia lying transversely between the cleft parent frustules; **6.** The same, viewed endways, showing their cylindrical figure; **7.** Increased growth of the sporangia; **8.** The produced sporangia ultimately much larger than parent fronds, and now striated like the latter. At the commencement of conjugation the fronds are enveloped in mucus, as shown. **9, 10, 11, 12.** Gomphonema curvatum (Thwaites), illustrating the process of conjugation in this being, which generally resembles that in Epithemia. **14.** Melosira nummuloides (Ralfs). **17.** Gomphonema minutissimum (Thwaites) conjugating. **18.** Dinophysis acuta (Ehr.), f. v. **19.** D. limbata (Ehr.), f. v. **20 & 27.** Melosira coarctata (Ehr.), f. vs. **21, 22.** Amphitetras antediluviana (Ralfs): **21.** A partial s. v.; **22.** filament. **24, 25.** Tetracyclus lacustris (Ralfs): **24.** Filament; **25.** A marginal view. **26.** Melosira sulcata (Ehr.), a filament. **28.** Actinoptychus Jupiter (Ehr.). **29.** Melosira Italica (Ehr.), filament. **30.** Sphenosira Catena (Ehr.), filament. **31.** Actinoptychus? hexaptera (Ehr.). **32.** Amphipentas? alternans (Ehr.). **33.** Asterolampra Marylandica (Ehr.). **34.** Asteromphalus Hookeri (Ehr.). **35.** Heliopelta Metii (Ehr.). **36.** Symbolophora Trinitatis (Ehr.). **37.** Spirillina vivipara (Ehr.): a member of the family Arcellina, having a close affinity with the calcareous-shelled Polythalamia or Foraminifera. **38.** Craspedodiscus elegans (Ehr.). **39, 40.** Coscinodiscus radiatus (Ehr.): **39.** f. v.; **40.** s. v. **41, 42.** Eupodiscus Argus (Ehr.): **41.** f. v.; **42.** s. v. (In fig. 41, the sites of the three tubular processes, which led Ehrenberg at first to call it Tripodiscus, are seen.) **43, 44.** Triceratium Favus (Ehr.): **43.** f. v.; **44.** s. v. **45, 46.** Climacosphenia moniligera (Ehr.): **45.** f. v.; **46.** s. v. **47.** Terpsinoë musica (Ehr.). **48, 49.** Grammatophora gibba (Ehr.): **48.** f. v., showing the two imperfect septa (vittæ, Kütz.) at each end; **49.** s. v. **50, 51.** Zygoceros Surirella (Ehr.): **50.** s. v.; **51.** f. v. **52, 53.** Grammatophora marina (Ehr.): **52.** f. v.; **53.** s. v. **54.** Hemiaulus antarcticus (Ehr.), f. v.

PLATE XII. (Diatoms, Protozoa, &c.).

Figure 1. Amphiprora constricta (Ehr.), f. v. **2, 3, 4.** Surirella Gemma (Ehr.): **2, 3.** f. v.; **4.** s. v.: these figures were intended especially to represent the foot-like processes (cilia?) and the foramina through which these are protruded. **5.** Navicula cuspidata (Ehr.), s. v. **6.** N. amphirhyncus (Ehr.), s. v. *** 7, 8, 9.** Stauroneis phyllodes (Ehr.): **7, 8.** s. v.; **9.** f. v. **10, 14, 30.** Stauroneis scalaris (Ehr.): **10.** s. v.; **14.** Process of self-division seen on f. v.; **30.** s. v. **11.** Campylodiscus flexuosa (Ehr.), f. v. **12, 13, 22, 23.** C. Ehrenbergii (Ehr.): **12 & 22.** f. vs.; **23.** s. v.; **13.** Viewed lying on one end. **15 & 31.** Navicula major (Ehr.): **15.** s. v.; **31.** f. v. **16.** Stauroneis dilatata (Ehr.), s. v. **17, 18.** S. Phœnicenteron (Ehr.): **17.** f. v.; **18.** s. v. **19, 20.** Surirella Craticula (Ehr.): **19:** f. v.; **20.** s. v. **21.** Navicula Tabellaria (Ehr.), s. v. **24, 25.** Epithemia Librile (Ehr.): **24.** f. v.; **25.** s. v. **26.** Amphora gracilis (Ehr.), s. v. **27.** Epithemia gibba (Ehr.), ventral surface. **28 & 53.** Gomphonema apiculatum (Ehr.): **28.** f. v.; **53.** s. v. **29.** Himantidium monodon (Ehr.), s. v. **32.** Navicula affinis (Ehr.), s. v. **33.** N. Chilensis (Ehr.), ventral surface, s. v. **34 & 36.** Synedra Gallionii (Ehr.): **34.** f. v. of four conjoined; **36.** s. v. **35.** Gomphonema Vibrio (Ehr.), s. v. **37.** Amphora navicularis (Ehr.), f. v. **38.** A. Libyca (Ehr.), f. v. **39.** Eunotia quinaria (Ehr.), s. v. **40.** Diadesmis lævis (Ehr.), f. v. **41.** Cocconeis Finnica (Ehr.), s. v. **42.** C. oceanica (Ehr.), s. v. **43.** Navicula Esox (Ehr.), s. v. **44.** Nitzschia valens (Ehr.), f. v. **45, 49, 50, 51, 52.** Himantidium Papilio (Ehr.): **45 & 51.** Filaments; **49.** A single frustule seen on ventral

surface; **50 & 52.** s. v. **46.** Cocconema cymbiforme (Ehr.), s. v. **47.** Peridinium constrictum (Ehr.): the median sulcus or constriction is well seen dividing the lorica into two segments—patellæ or valves, each of which is here again composed of several facettes. A distinct nucleus (sexual gland, Ehr.) is shown. **48** *a*, *b*. Cocconeis Americana (Ehr.): **48** *a*. s. v.; **48** *b*. Several frustules adherent to a portion of Conferva. **54.** Himantidium Guianense (Ehr.), f. v. of a filament. **55, 56, 57.** Colletonema Amphioxys (Ehr.): **55.** s. v. of a single frustule; **56.** f. v.; **57.** A collection enclosed in their mucous investment, seen in different positions. **58.** Sphærozosma? . . . (Brightwell): this production was found by Mr. Brightwell (see 'Fauna Infusoria of Norfolk'). We cannot perceive any affinity between his drawing and the members of the genus Sphærozosma, to which he has surmised it might belong. **59.** Ceratoneis Closterium (Ehr.), s. v. **60, 61.** Pleurosigma Fasciola (Ehr.). **62, 63.** Dictyocha Speculum (Ehr.): **62.** Viewed in front; **63.** Viewed sideways. **64.** Difflugia acanthophora (Ehr.): its surface illustrates what is termed an imbricate disposition of the scale-like markings; a navicular body is represented in its interior, as seen through its transparent lorica. **65, 66.** Asplanchna Brightwellii (Brightwell). These two figures are from Mr. Brightwell's book: **65** is there described as "a young specimen (female), just emerged, in which the red eye and germs of other organs are seen;" in **66** "may be seen the œsophagus leading to the stomach, and above the stomach two small bodies (either salivary or hepatic glands), and under it the opaque ovisac." **67, 68, 69.** Zoothamnium Arbuscula (Brightwell): these three figures from Mr. Brightwell illustrate the curious cycle in development referred to in the text. **70.** Vaginicola . . . ? (Brightwell): apparently a Vaginicola undergoing spontaneous fission. **71.** Mesocena heptagona (Ehr.). **72.** Navicula cardinalis (Ehr.), s. v. **73.** Stauroneis Isostauron (Ehr.), s. v.

PLATE XIII. (Diatoms).

Figure 1. Amphipleura pellucida. **2.** A. rigida. **3.** Surirella constricta. **4.** Denticula elegans. **5, 6, 7.** Amphiprora alata. **8.** Epithemia alpestris. **9.** Ceratoneis spiralis. **10.** Cocconema gibbum. **11.** Gomphonema curvatum. **12.** Epithemia Porcellus. **13.** (left) Podosphenia hyalina; (right) P. cuneata. **14.** P. Ehrenbergii. **15.** Rhipidophora tenella. **16.** Licmophora divisa. **17.** Rhipidophora Nubecula. **18.** Epithemia Musculus. **19.** Rhipidophora Meneghiniana. **20.** Synedra fulgens. **21.** Meridion circulare, var. **22.** Grammatophora hamulifera. **23.** Gomphonema acuminatum. **24, 25.** Odontidium hyemale. **26.** Tabellaria ventricosa. **27.** Rhabdonema Adriaticum. **28.** Pododiscus Jamaicensis. **29.** Tabellaria flocculosa. **30, 31, 32, 32** *a*. Biddulphia obtusa. **33.** Pyxidicula Adriatica.

PLATE XIV. (Diatoms).

Figures 1 to 12. Fragilaria capucina. **13.** Himantidium Soleirolii. **14.** Cymbosira Agardhii. **15.** Achnanthidium microcephalum. **16.** A. delicatulum. **17.** Cyclotella Scotica. **18, 19, 20.** Cymbella gastroides. **21.** Rhaphoneis Amphiceros. **22.** Encyonema prostratum. **23.** Hyalosira rectangula. **24–28.** Cymbella Helvetica. **29.** Hyalosira obtusangula. **30.** Sphenella angustata. **31.** S. obtusata. **32, 33.** Diadesmis confervacea. **34, 35** *a*, *b*. Berkeleya Adriatica. **36.** Gomphonema coronatum. **37, 38** *a*, *b*, *c*. Homœocladia pumila. **39–42.** Micromega pallidum. **43, 44.** M. bombycinum. **45, 46.** Homœocladia moniliformis. **47–49.** H. Martiana.

PLATE XV. (Diatoms).

Figures 1, 2. Cyclotella atmospherica (Ehr.). **3.** C. Atlantica (Ehr.). **4.** C. Sinensis (Ehr.). **5.** Staurosira construens (Ehr.). **6, 7, 8, 9.** Epithemia longicornis (Ehr.). **10.** Goniothecium crenatum (Ehr.). **11.** Epithemia Argus (Ehr.). **12.** Navicula didyma (Ehr.). **13.** Desmogonium Guianense (Ehr.). **15.** Navicula tæniata (Ehr.). **16, 17.** Himantidium monodon (Ehr.): **16.** Two frustules conjoined in front view; **17.** s. v. **18, 19, 20, 21.** Arachnoidiscus ornatus (Shadbolt): **18.** External membrane, as seen when detached from the inner framework, or when viewed from the outside of the shell as an opaque object; **19.** The inner framework is exhibited on a black disc as an opaque object; **20.** The membrane and framework united, as seen by transmitted light, ×200; **21.** The same, more amplified, ×500. **22, 23.** Campylodiscus parvulus (Smith): **22.** s. v.; **23.** Partial f. v. **24, 25.** Grammonema Jurgensii (Ralfs): **24.** Front and s. v. of a single frustule; **25.** A filament. **26, 27.** Melosira Nägeli: a series of figures to illustrate the distribution of the chlorophyll (endochrome), and the presence of a nucleus: **26** *a*. viewed from the base;

26 *b*. from the lateral surface; two bands of chlorophyll are seen on each side, and their section at the angles; **26** *c*. from the base; **27**. Seen from below, nucleus with nucleoli and sap-currents; large and small chlorophyll-globules; **27** *b*. Seen from the side; the two lateral bands of chlorophyll are seen, and a parietal nucleus, with sap-currents from it, in the centre of one side; **27** *c*. An individual after division, seen from the side. The chlorophyll bands appear only in section. Each secondary cell has a parietal nucleus. **28** *a*, *b*, *c*, *d*. Bacillaria Nägeli: *a*, viewed from the broad side, a granular nucleus in the centre; *b*, also the broad side, an individual before division, the nucleus primarily divided; *c*, division complete; *d*, viewed from the base (in section). **29** *a*, *b*, *c*, *d*. Melosira Dickieii (Thwaites): *a*, filament, in ordinary state; *b*, filament, the terminal cells of which are becoming converted into sporangia; *c*, sporangia; *d*, sporangial frustules becoming developed from one of the halves of a previously divided sporangium, ×220. **30** *a*, *b*. Mastogloia Dansei (Thwaites): *a*, portion of frond, ×35; *b*, a part of same, ×220. In it two frustules are shown, one in front, the other on side aspect. **31** *a*, *b*, *c*, *d*. Dickieia ulvoides (Ralfs): *a*, natural size, in different stages of growth; *b*, frustules (navicular bodies) highly magnified when fresh; *c*, one when dried; *d*, a lateral view of the same; *e*, a portion of frond, less highly magnified, showing the simple and binate frustules. **32**. Melosira varians (Thwaites) (=Gallionella, Ehr.), filament with sporangia, ×220. **33**. M. Italica, filament with sporangia. **34**. Dictyocha Fibula. **35**. D. trifenestra.

PLATE XVI. (Diatoms and Desmids).

Figures 1 to 6. Navicula (Pinnularia, Ehr.) major. From Schleiden's 'Principles of Botany,' to illustrate the structure of the silicious valve. **1.** s. v. (venter, Ehr.). "In the middle line are two clefts, terminating at the centre, as well as at the other ends, with a little circular enlargement, more clearly seen in figs. **3** and **5**. The rounded spot in the middle, and at the two ends, is not a hole as represented by Ehrenberg. That such a hole is decidedly sometimes not present, is seen in such fragments as figs. **3** and **5**. In the position of the oblique lateral clefts (striæ or costæ, Ehr.), the valve consists of two leaves, penetrated by the clefts, which, where both the lamellæ touch each other, are somewhat broader, which explains the varying breadth of the clefts according to the alteration of the foci. Fragments in which this structure is clearly represented may be frequently obtained by crushing the valve (fig. **6**). **2.** A front view, showing that the rounded enlargements of the median line are but depressions on the external surface. The double contour, denoting the thickness of the wall, is well seen. This clearly shows that a passage exists from the top to the bottom of the valve, which may be easily confirmed if the valve, or better still an oblique section of it, be looked at from above; fig. **5** is such a section." **7, 8.** Cymatopleura elliptica (Smith). **9.** C. Solea. **10**-**19.** Closterium Ehrenbergii (Smith), showing the stages in its conjugation, and the formation of the sporangia: **10.** A single frond in its ordinary condition; **11.** Two fronds approaching to conjugate; **12.** Conjugating fronds undergoing self-division, the upper showing the protuberances through the torn apices of which the contents of the divided fronds pass into the sporangia; **13.** Shows the passage of the endochrome-sac and its contents; **14.** Conjugated fronds having perfected their sporangia; **15** (after M. Morren). Development of the "propagules" into young fronds; **16, 17, 18, 19** (from Morren). Development of a sporangium into a Closterium with unequal segments: the figures are all magnified 100 times. **20**-**26.** Surirella biseriata (Smith). To illustrate the structure of the valve and self-division of the frustule: **20.** View of frustules on the completion of self-division; **21.** Apertures of costal canals seen in front; **22.** Silex of connecting membrane after maceration in acid; **23.** f. v. (the broad median longitudinal band is the connecting zone of the two valves); **24.** s. v.; **25.** e. v.; **26.** Transverse section of empty frustule.

PLATE XVII. (Diatoms and Phytozoa).

Figures 506 509. Pyxidicula globata. **511 & 515.** Xanthidium? ramosum. **512.** X. hirsutum. **513, 514.** X.? difforme. **516**-**518.** Campylodiscus Clypeus. **519**-**531.** Spirillum Bryozoon. **532, 533.** Astasia navalis. **534.** Gyges sanguineus.

PLATE XVIII. (Phytozoa).

Figure 1. Monas Crepusculum, ×800. **2.** Monas Punctum. **3, 4.** Uvella Glaucoma, × 350: **4.** Detached monads. **5.** Polytoma Uvella. **6.** Microglena monadina. **7.** Gle-

nomorum tingens, ×250. **8.** Doxococcus ruber. **9.** Bodo intestinalis, ×300. **10 & 21.** Monas Lens. **11** *a*, *b*. Cercomonas lobata. **12** *a*, *b*. C. truncata. **13** *a*, *b*. Amphimonas dispar. **14.** Chilomonas Paramecium, ×380. **15.** Monas elongata. **16.** Trepomonas agilis. **17.** Monas globulosa. **18.** Chilomonas granulosa. **19.** Monas attenuata. **20.** Cercomonas acuminata. **21.** Monas Lens (two figs.). **22.** Cercomonas longicauda. **23.** C. Globulus. **24.** Spiromonas volubilis. **25.** Pleuromonas jaculans. **26.** Heteromita exigua. **27.** Trepomonas agilis. **28** *a*, *b*, *c*, *d*. Trichomonas Batrachorum. **29.** Cryptomonas ovata, ×300. **30.** Prorocentrum micans. **31.** Lagenella euchlora. **32.** Cryptoglena conica. **33, 34.** Trachelomonas Volvocina. **35** *a*, *b*, *c*, *d*. Chonemonas Schrankii: *c*, *d*. Var. C. unifilis. **36.** Astasia hæmatodes. **37–39.** Euglena sanguinea. **40, 51, 54.** E. viridis, encysted and in act of fission. **41, 42.** E. Pyrum, ×400. **43, 44.** E. longicauda. **45.** Amblyophis viridis. **46.** Euglena viridis. **47.** Chlorogonium euchlorum. **48** *a*, *b*, *c*. Astasia limpida. **49, 50.** A. contorta. **52.** Euglena spirogyra. **53, 55.** Eutreptia viridis. **56.** Zygoselmis inæqualis. **57.** Bacterium triloculare. **58.** Spirochæta plicatilis. **59.** Spirillum Undula. **60.** Vibrio Bacillus. **61.** Spirillum Undula. **62.** Vibrio Bacillus. **63.** Spirodiscus fulvus. **64.** Vibrio Rugula. **65, 66.** Sporonema gracile. **67, 68.** Spirulina plicatilis. **69.** Zooglœa Termo: a mucoid mass of Vibrios, the individuals of which are equivalent to Bacterium Termo of Dujardin.

PLATE XIX. (PHYTOZOA).

Figure 1. Chromatium Weissii. **2.** Menoidium pellucidum. **3.** Tetramitus descissus. **4–6.** Mallomonas Plöslii. **7** *a*, *b*, *c*. Phacotus viridis. **8.** Anisonema Acinus. **9, 10.** Trypemonas volvocina. **11.** T. cylindrica. **12.** Chonemonas acuminata. **13, 14.** Lepocinclis Globulus. **15.** Hirmidium inane. **16.** Chlamydomonas pulvisculus. **17.** Dinema griseolum. **18, 19.** Eutreptia viridis. **20–31.** Chlamydococcus (Protococcus) pluvialis, its forms and development, after Cohn: **20.** A still cell revived after desiccation; **21.** Cell with nucleus; **22.** Still cell with dense external coat; **23.** Fission of primordial within the parent cell; **24.** Fission of a still cell, wall of parent cell become gelatinous; **25.** Division of secondary cells; **26.** Fission of encysted cell into four secondary, and **27.** into thirty-two cells; **28.** The several cells produced set free, a membrane thrown out around one; **29.** An irregular-shaped, Euglena-like zoospore; **30.** A cell on the point of assuming the motile condition; **31.** A very small, globular, encysted zoospore. **32–37.** Gonium pectorale: **32.** A perfect tabular frond; **33.** Detached cells, showing their contractile vesicles; **34.** Four cells (gonidia) united by the radiating tubular processes of their external membrane, into which the green contents do not enter; **35.** Excepting one cell of the tablet, all the others have proceeded, to a greater or less extent, by the process of fission, to generate "daughter cells," or the rudimentary gonidia to form new tablets; each one is still surrounded by the "mother-cell" wall; **36.** A tablet, of which the original gonidia are widely separated, and loosely held *in situ* by the external cell-wall; fission has further proceeded, and rudimentary tablets formed from each original gonidium, consisting of sixteen "daughter cells" (macrogonidia); in **37** the connecting bonds are quite dissolved, and the sixteen secondary tablets set free: all ×500. **38–58.** Stephanosphæra pluvialis, exhibiting its forms and modes of development: **38.** An equatorial view; **39.** Lateral view, gonidia spindle-shaped, with protoplasmic elongations; **40.** Division of gonidia into four "daughter cells"; **41.** Further divided into eight, united in an annular form; **42.** A further-advanced stage, macrogonidia now forming distinct families, like the one represented in fig. 57; **43.** Division of gonidia preparatory to forming microgonidia; **44.** A full-grown resting cell; **45.** Beginning of division of a resting cell; **46.** Division into four, outer membrane disappeared; **47.** Tapering of one end of secondary or "daughter" cell preparatory to formation of cilia; **48, 49.** Naked zoospores; **50.** Encysted zoospore (gonidium); **51.** Resolution of all the gonidia, except one, of a mature Stephanosphæra into microgonidia; **52.** Detached ciliated microgonidia; **53.** An encysted zoospore with protoplasmic elongations of the primordial cell; **54, 55.** Division of encysted zoospore; **56.** More advanced stage of division; **57.** A young family of eight cells; **58.** Another, with the cellular envelope still visible within the membrane of the mother cell: ×500 (Cohn). **59–69.** Pandorina Morum: **59.** Perfect form, with sixteen gonidia, side view; **60.** The same, polar view; **61.** A gonidium, side view; **62.** A frond with the gonidia divided; **63.** A more advanced frond; **64.** A young frond of fig. **63**, after formation of cilia, set free; **65, 66.** Young fronds, gonidia pushed close together; **66.** A polar view; **67.** End or polar view of a frond like **65**, the gonidia of which are encysted and turned red and their gelatinous envelope nearly dissolved; **68.** A side view of the same; **69.** A single encysted gonidium. Figs. 59 to 68 (except 61), ×100; figs. 61 & 69, ×400 (Henfrey).

PLATE XX. (PHYTOZOA).

Figures 1–14. Polytoma Uvella, forms and development of: **1.** Perfect form; **2.** Same, acted on by chromic acid, which has separated the primordial cell from the external envelope; **3–6.** Stages of fission-process; **7.** Resting stage; **8.** External membrane broken up into granules; **9.** Fission into four; **10–12.** Arrangement of secondary or "daughter" cells; **13.** Contraction of body within external envelope; **14.** Body retracted from anterior extremity: ×300 (Schneider). **15–21.** Fission and formation of microgonidia in Chlorogonium euchlorum. **22, 23.** Pandorina Morum (?): **22.** A presumed form of, with encysted immature fronds, ×150; **23.** Another presumed form, ×220. **24.** Chlamydococcus (?), a presumed form of; the two internal globular cells of a clear ruby-crimson; the moving granules probably monads; suggested to be Spermatozoa, ×220 (Currey). **25.** Volvocina, a developmental phase of one of the, having encysted gonidia. **26–28.** Syncrypta Volvox, ×260. **29, 30.** Synura Uvella: **30.** Section of a group (Ehr.). **31.** Uroglena Volvox. **32.** Volvox Globator. **33–49.** Illustrations of structure and development of Volvox Globator (Busk and Williamson): **33.** A section showing parietal cells and contained gemmæ; **34.** Portion of edge of an embryo Volvox viewed in the equatorial plane to show the common envelope and the position of the subjacent cells or gonidia; the last not passing beyond the external gelatinous (?) coat (Busk); **35.** Highly magnified view of three cells; the faint lines between indicate the limits of the gelatinous envelope of each cell; **36.** Section of a specimen mounted in glycerine (Will.); **37.** Cells seen from above, showing radiating threads; **38.** Oblique section, mounted in glycerine; **39–41.** Single cells; **42–44, 46, 47.** Progressive development of Volvox by fission; **45.** Diagram of a superficial view of a portion of a globe (Will.); **48, 49.** Winter spores of Volvox aureus: **48.** An earlier; **49.** A later and mature condition (Busk).

PLATE XXI. (PROTOZOA).

Figure 1. Amœba Schultzii, ×330. **2.** A. globularis, ×330. **3.** A. porrecta, ×330. **4.** A. princeps, ×100. **5** *a*, *b*, *c*. Amœbiform germs or "Proteans" of Spongilla. **6.** Miliola vulgaris. **7–9.** Arcella vulgaris; **8.** A side view; **9.** Empty shell. **10.** Difflugia globulosa, ×150. **11.** Euglypha alveolata, empty shell, ×340. **12–14.** Gromia oviformis: **12.** A young specimen; **13, 14.** Nuclear bodies found in (Schultze), ×300. **15.** Arcella Okenii. **16.** Gromia oviformis, ×300. **17.** Difflugia pyriformis. **18** *a*, *b*. Supposed young forms of Gromia Dujardinii: *a*, ×72; *b*, ×180. **19** *a–f*. D. Enchelys: *a*, *b*. Different forms; *c*. Contents resolved into granules; *d*, *e*. Fission into two and four portions; *f*. Two individuals coherent. **20** *a*, *b*. Early stage of an undescribed Miliola: *a*, ×72; *b*, ×330 (Schultze). **21, 22.** Miliola obesa: **21.** A young specimen, ×72; **22.** Shell, after the removal of the calcareous matter by dilute acid. **23.** M. Anconensis. **24.** Animal contents of a Miliola after dissolution of the shell by acid; displaying a constriction at each half turn, and the delicate membranous envelope at the lower and larger extremity. **25.** Cornuspira perforata. **26.** Rotalia Veneta, seen in front. **27.** Rosalina ornata, portion of shell of, ×100. **28.** Polystomella venusta, ×72. **29, 30.** P. Stella-borealis, seen in front, ×72; **30.** Portion of cell to show structure, ×180. **31.** Rotalia Veneta, shell after action of acetic acid, ×180. **32.** Nuclear body from the last chamber of Textilaria picta, ×330. **33.** Rotalia Veneta, ×50. **34** *a*, *b*. Acervulina acinosa; *b*. Natural size. **35.** Acervulina globosa, portion of shell, ×300. **36.** Textilaria picta, ×180. **37.** Acervulina globosa, section through thickness of shell, ×300. **38.** Polymorphina silicea, silicious matter detached by pressure, ×300. **39.** Polystomella strigilata, animal substance with attached particles apparently assuming an independent existence, ×330. **40.** Portion of contents of Gromia Dujardinii. (Figures 20 to 40, Schultze.)

PLATE XXII. (PROTOZOA).

Figures 1–3. Amœba radiosa; **2.** An older specimen; **3.** One nearly divided into two. **4, 5.** A. Limax. **6.** A. guttula. **7–11.** A. bilimbosa: in **7** and **9** the external envelope strongly marked by a double outline; a clear zone within it; **9.** First stage of encysting; **10.** A nucleus with a central clear space, and one with two nucleoli; **11.** A specimen acted on by solution of iodine; contained starch-granules coloured blue. **12–18.** A. actinophora: in **13** two pulsating vesicles occur; **15.** Specimen acted upon by acetic acid, showing double outline of integument; **16** contains refracting particles of a crystalline form; **17.** Some such particles isolated, and more highly magnified; **18.** Two coherent individuals, indicative either of fission or of conjugation. **19.** Cadium marinum. **20–23.** Amœba bilimbosa: **20.** Treated with iodine, the starch-granules coloured blue;

21. An encysted specimen; **22.** A ruptured and empty cyst; **23.** Probably the act of fission. The large circular body lying between the two halves is an encysted Oxytricha which has been taken up by the Amœba. **24–27.** Cyphidium aureolum. **28, 29.** Gregarina Sipunculi; **29.** A double being, the result of fission. **30–32.** Progressive development of the contents of a Gregarina from an Annelid (Cœnurus variegata) into pseudonavicellæ,—in other terms, three pseudo-navicella capsules. **33.** G. clavata. **34.** G. Sieboldii, full-grown. **35, 36.** G. Terebellæ; **36** exhibits longitudinal costæ. **37.** A group of Psorospermia, from a cyst in the eye of a Cyprinus Tinca. **38** *a, b, c.* Full-grown Psorospermia: *a*, viewed in front, ×900; *b*, seen from above; *c*, on one side. From the vesicula of Gadus lota. **39.** Psorospermia from a cutaneous cyst on a Gasterosteus (Stickleback), ×580. **40.** Psorospermia from a cyst of Gosterosteus aculeatus; a group showing the different stages of development. **41.** Psorospermia burst by pressure from Cyprinus Brama; *b*, the contained amœbiform body isolated, ×900. **42.** Epipyxis Utriculus. **44, 45.** Microtheca octoceros. **46.** Opalina Lumbrici. **47.** O. armata, transverse fission. **48, 49.** Dinobryon Sertularia.

PLATE XXIII. (Protozoa).

Figures 1, 2. Actinophrys, figured as one phase in the development of Vorticella microstoma by Stein: *a*, external coat; *b*, nucleus; *c*, vesicle. In **2** a ciliated embryo appears within a distinct sac. **3–5.** Podophrya fixa (?), represented by Stein as another phase, besides figs. 1 and 2, in the development of Vorticella microstoma. A ciliated germ is seen in **4**, which in **5** is about to escape. **6–8.** Other forms of Podophryean Acinetæ as figured by Stein: **6, 7.** As treated with acetic acid; the development of an embryo from the nucleus is shown in figs. **7** and **8.** **9–14.** Vorticella-cysts, after Stein's figures. In **9** the nucleus is resolved into monadiform germs; **10, 11.** Development of cyst-contents into secondary cysts, which are further seen in figs. **12** and **13** as become fusiform and protruded through the wall of parent cyst, so as to discharge their monadiform germs without, as seen in fig. **14.** **15, 16.** Acineta diademiformis, with its embryo. **17–20.** A. linguifera, or Acineta with the tongue-like process attributed to Opercularia berberina; **20** shows an empty capsule. **21.** A. digitata, or Acineta with the finger-like processes. **22, 23.** Acineta attributed by Stein to Opercularia Lichtensteinii; **23.** A specimen acted on by acetic acid. **24, 25.** Actinophrys oculata; **25** represents three individuals in the act of conjugation, treated with acetic acid. The contents of two have intermingled; a large vacuole with food-particles lies between them. The individual on the other side is simply coherent. (1–26, Stein.) **26, 27.** Acineta ferrum-equinum; **27** shows the escape of the ciliated embryo. The horseshoe-shaped nucleus appears as a clear space. **28.** Actinophrys Sol. **29, 30.** A. Eichhornii; **30.** A highly magnified section to show the reticulated structure. **31, 32.** A. Sol: **31.** In the act of self-division (conjugation ?); **32** shows three vesicular expansions concerned in the introduction of food, and an encysted animalcule just brought to the surface. **33–35.** Podophrya fixa; **34.** In act of fission; **35.** Segment becoming one independent and about to separate. **36, 37.** Encysted Podophryæ. **38, 39.** Stages of Podophrya towards encysting. **40, 41.** Acinetæ with embryos. **42, 43.** Transformation of the embryo into an Acineta, figured as commencing in **43**, and as completed in **42.**

PLATE XXIV. (Protozoa).

Figures 274, 275. Lacrymaria Proteus. **276, 277.** Leucophrys patula. **278.** L. Spathula. **279, 280.** L. sanguinea. **281.** Holophrya Ovum. **282, 283.** Prorodon teres. **284–286.** Coleps hirtus. **287, 287*, 288, 289.** Trachelius Anas. **290.** T. Ovum. **291–293.** Loxodes Rostrum. **294.** Bursaria Vorticella. **295.** B. leucas. **296.** B. Pupa. **296*.** Spirostomum virens. **297, 298.** S. ambiguum. **299.** Phialina viridis. **300–302.** Glaucoma scintillans. **303–309.** Chilodon Cucullulus. **310, 311.** Nassula elegans. **312, 313.** Amphileptus Anser. **314–316.** A. Fasciola. **317–319.** Trachelocerca Olor. **320.** T. biceps.

PLATE XXV. (Protozoa).

Figures 321–323. Aspidisca denticulata. **324–328.** Kolpoda Cucullus. **329–332.** Paramecium Aurelia. **333.** Uroleptus Musculus. **334, 335.** Ophryoglena acuminata. **336, 337.** Oxytricha gibba. **338, 339.** Ceratidium cuneatum. **340, 341.** Kerona polyporum. **342.** Urostyla grandis. **343, 344.** Stylonychia lanceolata. **345, 346.** Discocephalus rotatorius. **347, 348.** Himantophorus Charon. **349.** Chlamidodon Mnemosyne. **350–353.** Euplotes Charon. **354, 355.** Ptygura Melicerta. **356.** Ichthydium Podura. **357, 358.** Chætonotus Larus. **359, 360.** Glenophora Trochus. **361–364.** Œcistes crystallinus. **365–370.** Conochilus Volvox.

PLATE XXVI. (Phytozoa).

The following figures are derived from M. Dujardin's exeellent treatise, 'Histoire des Infusoires':—**Figure 1.** Hexamita nodulosa. **2.** Anthophysa Mülleri. **3, 4.** Acineta tuberosa; in **4** the cilia included. **5.** Heteromita ovata. **6.** Crumenula texta. **7.** Polyselmis viridis. **8.** Anisonema sulcata. **9** *a*, *b*. Oxyrrhis marina. **10** *a*, *b*. Plœotia vitrea. **11.** Heteronema marina. **12** *a*, *b*. Zyzoselmis nebulosa. **13.** Peranema globulosa. **14.** Cyclidium distortum. **15.** C. abscissum. **16** *a*, *b*. Acomia Cyclidium; *b*, self-dividing.

PLATE XXVII. (Protozoa).

Figures 1–9. Vorticella microstoma: **1.** With a bud growing from its base; **2.** A specimen about to detach itself from its stalk, and having a posterior wreath of cilia; **3.** Self-division proceeding; in **4** complete; **5** *a*, *b*, *c*, *d*. Encysting-process; **5** *e*. A cyst ruptured by pressure, giving exit to the included Vorticella, apparently unchanged; **6.** Supposed transitional forms from rudimentary campanulate organisms to undoubted Vorticellæ; **7–9.** Process of encysting, and progressive disappearance of special organs. **10–15.** Vaginicola crystallina: **10.** Self-division; **11.** One of the fission-products contracted and ready to escape by means of its posterior wreath; **12–15.** Acinetæ formed from Vaginicolæ. **16–23.** Epistylis nutans: **16:** Two individuals on a stem; the ciliary apparatus protruded in one, contracted in the other; **17, 18.** Supposed Acinetæ; Acineta-body of the Epistylis; in **17** the wavy outline indicates the contractions taking place in the integument; in **18** the outstretched ciliary fibres or processes, two nuclei, and a large contractile vesicle are visible; **19.** Another such body, with its surface much contracted, and its contained substance wasted by the development of embryonic nuclei; **20.** Another figure assumed by the Acineta-body; **21.** The ultimately withered state arrived at by the Acineta-body of an Epistylis, after the exhaustion of its contained formative blastema by the repeated production of embryos; **22, 23.** Very young forms (probably) of the Epistylis nutans, and apparently the Epistylis Botrytis of Ehrenberg.

PLATE XXVIII. (Protozoa).

Figures 1–3. Nassula ambigua: **1.** Under surface; the two long articulated filaments within are portions of Oscillatoriæ; *c*, vesicle; *d*, nucleus; **2.** Encysted specimen; **3.** Animalcule forced from its cyst by pressure. **4–7.** Glaucoma scintillans: **4.** Under surface; **5.** An encysted being, seen in **6** undergoing transverse fission, which in **7** appears oblique, owing to a change of position of the resulting segments. **8, 9.** Prorodon teres: **9.** Its nucleus surmounted by a rim-like nucleolus. **10.** Stylonychia Mytilus. (1–10, Stein.) **11–15.** Nassula elegans: in **11** internal germs occur in a cavity (uterine) communicating externally by a canal (oviduct); **12.** Germ loosing itself from the parent; **13.** A fission-product enclosing a germ; **14.** Germ developing Acinetiform tentacles; **15.** Nucleus terminated at its narrow end by a nucleolus. **16.** Stentor Mülleri, surrounded by an envelope with monads in its interior; **17.** Same, animal contracted in its case. (11–17, Cohn). **18, 19.** Vaginicola valvata. The valve is seen closed at *b* in fig. **18**; fission has occurred both in this and in **19**, but the animal is contracted in the former, and expanded in the latter example; in **19** the valve appears as a streak parallel with one side. **20–23.** Lagotia viridis: **20.** Head of a young individual; **21.** Lateral view of animal and of its ciliated head; **22.** Tip of one of the lobes of ciliated head; **23.** Animal with front view of head. (18–23, Wright.) **24–26.** Otostoma: the oral cavity is seen as an ear-shaped space; in **25** two vesicles also are seen opening externally. (Carter.) **27–30.** Cœnomorpha Medusula. **31.** Panophrys griseola. **32.** Habrodon curvatus. **33, 34.** Blepharisma hyalina. **35.** Cinetochilum margaritaceum. **36, 37.** Cyclogramma rubens. **38, 39.** Stichotricha secunda. **40–42.** Ptyxidium ovulum; in **42.** Act of fission. **43, 44.** Stichotricha secunda. **45.** Colobidium pellucidum. **46, 47.** Mitophora dubia. **48, 49.** Apionidium modestum. **50, 51.** Lembadion bullinum. **52–54.** Bæonidium remigans. **55–57.** Opisthiotricha tenuis. **58–60.** Megatricha partita. **61.** Acropisthium mutabile. **62, 63.** Siagontherium tenue. (27–63, Perty.) **64** *a–k*. Enchelys Farcimen, illustrating change of form consequent on the introduction of food. **65–71.** Nassula viridis: **65.** Natural form, ×370; **66, 67.** Cysts; **70, 69, 68, 71.** Development of cyst-contents into monadiform germs, enclosed within saccular thecæ, and at length discharged externally as in fig. **71**:

×300 (Cienkowsky). **72, 73.** Enchelys Pupa. **74–76.** Stylonychia pustulata: **74.** the animalcule encysted, ×300. **75, 76.** Rotating cells within the cysts, ×220 (Cienkowsky).

PLATE XXIX. (Protozoa.)

Figure 1. Vorticella Campanula, viewed from the ventral aspect. **2.** Carchesium polypinum, viewed in front and directly upon the ciliated disc: *i*, the mouth; *e*, the anus. **3.** Scyphidia limacina. **4.** Opercularia berberina, seen from the back. **5, 6.** Chætospira Mülleri: **6** represents the animal in motion. **7.** Stentor polymorphus, showing vascular canal around the head and along one side. (1–7, Lachmann.) **8–13.** S. cæruleus, and its supposed internal germs or embryos in different stages of development (Eckhard). **14, 15.** Trichodina Pediculus: **14.** A lateral view; **15.** Anterior extremity. **16.** T. mitra. **17.** T. Pediculus, a dead, distended specimen. (14–17, Stein.) **18.** Stylonychia pustulata, encysted (Stein). **19, 20.** Amphileptus fasciola: seen encysted in fig. 19, and as escaped from the cyst in fig. 20. **21–24.** Oxytricha Pellionella: **21.** Encysted; **22.** Cyst acted upon by hydrochloric acid; **23.** Animal revived in its cyst prior to its escape; **24.** The free animal. **25–34.** Paramecium (Loxodes, Cohn) Bursaria, its structure and development: **25** to show circulation of contents; **26.** Portion of integument highly magnified; (19–26, Cohn;) **27.** Transverse fission; **28.** Nucleus seen at *c*, the nucleolus at *d*; **29.** Embryo attached to the nucleus; **30.** Embryo escaped but still adherent by acinetiform tentacles; **31.** Nucleus and attached nucleolus separated by acetic acid; **32, 33.** Nucleus and nucleolus during fission of animal; **34.** Nucleus, nucleolus, and commencing embryo. **35–47.** Kolpoda Cucullus, illustrating its forms and development: **37.** Acted on by alcohol, to bring its nucleus into view; **38.** An animal contracted into a spherical shape; **39.** A similar one undergoing fission; **40.** Encysted Kolpoda; **41.** Same, in act of fission; **42.** Fission completed; **43.** Specimen treated with alcohol; **44.** Cyst-contents divided into four; cyst-wall soft and irregular; **45.** Embryo escaping from a cyst; **46.** A ruptured cyst giving exit to encysted germs, as seen in **47.** **48–59.** Chilodon Cucullulus: **48** *b*. The so-called dental cylinder; *c*, nucleus and nucleolus; **49.** A specimen with a large upper lip, equivalent to C. uncinatus (Ehr.); **50.** Transverse, and **51.** Longitudinal fission; **52.** Contracted prior to encysting; **53, 54.** Cysts; in **54** an embryo developed; **55.** Apparently laminated cyst discharging its contents; **56, 57.** An empty cyst, with the aperture through which its contents have escaped remaining; **58.** A cyst containing a parent animal and an embryo; **59.** A liberated embryo, equivalent to Cyclidium Glaucoma (Ehr.). (26–59, Stein.)

PLATE XXX. (Protozoa, after Stein).

Figures 1–4. Opercularia articulata: **2.** A highly magnified view of the head; **3, 4.** Supposed Acinetæ of this species; an embryo shown in fig. 4. **5–8.** Ophrydium versatile: In **5** the animal is seen extended, and in **6** contracted; **7.** Encysted animal; **8.** Its supposed Acineta. **9, 10.** Carchesium polypinum: **10.** A highly magnified view of its stem. **11.** Epistylis crassicollis. **12.** Cothurnia curva. **13, 14.** C. Sieboldii: **14.** A side view. **15, 16.** C. Astaci: **16.** Animal contracted. **17–26.** Spirochona gemmipara, and its development: **17** exhibits a gemma; **18–20.** Progressive development of the spiral head in a gemma; **21.** Encysted gemma; **22.** Supposed Acineta (the Dendrocometes) in its early stage; **23.** As fully developed; **24.** Embryo (seen in **23**) set free; **25.** A Dendrocometes, without arms, but with a contained embryo; **26.** A free embryo revolving on its long axis. **27, 28.** Spirochona Scheutenii; **28.** After the action of spirit of wine. **29–36.** Lagenophrys Vaginicola, its structure and development: In **29** a gemma is seen in the act of fission; in **30** the animalcule has its rotatory apparatus retracted; **31** shows the detachment of the head of the animal from the mouth of its sheath, to allow escape of a gemma; **32.** Act of fission; **33.** Formation of a gemma at posterior extremity; **34.** Several gemmæ enclosed; **35, 36.** Act of fission; complete in fig. **35**, where the parent segment is detached from the orifice of the sheath, leaving a portion of its interior extremity. **37.** Opercularia microstoma: A, extended; B, contracted.

PLATE XXXI. (Protozoa).

Figures 1–4. Bursaria leucas, and the position and structure of the trichocysts found in its integument: **1.** ×90; **2.** Diagram of the margin, to show position of trichocysts in the dermal layer; **3.** Trichocysts projected from the surface after the application of acetic acid; **4.** Detached spiral trichocysts in the second stage of evolution from elongated oval corpuscles (Allman). **5–6.** Corethria Sertulariæ: in **5** the two sorts of processes are both seen; that in the right is the normal form; **6.** More magnified view of the fusiform process, showing the terminal depression or aperture. **7–13.** Lagotia producta, its structure and development: **7.** Animal extended, in **8** contracted; **9, 10, 11.** Larva or embryo; **10** represents it attached; **12.** Diagram of structure of the sheath, showing the ectoderm (colletoderm) at *a*, the chitinous tube at *b*, and the endoderm at *c*; *d* points out the mode of overlapping of the several segments of tube; **13.** Highly magnified view of a portion of tube. **14, 15.** Zooteirea religata: **14.** Animal expanded; **15.** Contracted. (5–15, Wright.) **16–20.** Peridinium uberrimum: **17.** Seen on opposite side to that shown in 15; **18.** Transverse fission; **19.** Same specimen after the application of solution of iodine; **20.** Nucleus isolated (Allman). **21, 22.** P. depressum: **21.** A side-, **22.** A front-view. **23.** P. longipes. (16–23 after Bailey.) **24–27.** Dysteria armata: **25.** Parts of mouth; **26, 27.** Process between two styles: **26.** A front-, and **27** A side-view (Huxley). **28.** Turbanella hyalina, dorsal view: *d*, the muscular œsophagus; *g*, testis; *f*, mature egg; *e*, ovary (×350). **29, 30.** Chætonotus maximus: **29.** Dorsal view (×350); **30.** A lateral view. **31.** Ideal section of Turbanella hyalina through the generative organs. (28–31, Schultze.) **32–39.** Noctiluca militaris: (**32.** N. punctata, Busch: *a*, oral cavity or hilum; *b*, sharp-bordered rod; *c*, nucleus; *d*, proboscis [cilium]; *f*, brown corpuscles, after Busch;) **33.** Front view, *a*, the tooth; *b*, oral aperture; *c*, position of supposed anus (after Webb); **34.** Dorsal view, showing the groove; and **35.** A latero-inferior view, displaying the oral cavity with the tooth, *d*; the cilium a gastric pouch, *e*; and a presumed anal aperture (Huxley); **36–39** (after Busch): **36.** A germ in process of development; **37.** Brown granular body, seen at *f* in fig. 32; **38.** A germ; **39.** Further advanced, acquiring the characters of a Noctiluca.

PLATE XXXII. (Rotatoria).

Figures 371, 372. Microcodon Clavus. **373.** Cyphonautes compressus. **374–378.** Megalotrocha albo-flavicans. **379–382.** Tubicolaria Najas. **383, 383*.** Stephanoceros Eichhornii. **384, 385.** Floscularia ornata. **386, 387.** Melicerta ringens. **388–392.** Limnias Ceratophylli. **393.** Enteroplea Hydatina. **394.** Hydatina senta. **395, 396.** Pleurotrocha gibba.

PLATE XXXIII. (Rotatoria).

Figures 397, 398. Furcularia Reinhardtii. **399 & 417.** Monocerca bicornis. **400–402, & 425.** Polyarthra platyptera. **403.** Diglena lacustris. **404, 405.** D. grandis. **406–408.** Triarthra longiseta. **409.** Rattulus lunaris. **410, 411.** Distemma Forficula. **412 & 414.** Triophthalmus dorsalis. **415.** Eosphora Najas. **416.** Notommata Copeus. **418–420.** N. Myrmeleo. **421.** N. Tigris. **422.** Synchæta pectinata. **423, 424.** Scaridium longicauda.

PLATE XXXIV. (Rotatoria).

Figures 425*, 426. Cycloglena Lupus. **427–429.** Theorus vernalis. **430–433.** Lepadella ovalis. **434–437.** Monostyla quadridentata. **438–440.** Mastigocerca carinata. **441–444.** Euchlanis? triquetra. **445, 446.** E. Lynceus. **447–453.** Salpina mucronata. **454–456.** Dinocharis Pocillum. **457–459.** Monura dulcis. **460–462.** Colurus deflexus. **463–465.** Metopidia Lepadella. **466, 467.** Stephanops lamellaris. **468, 469.** Squamella oblonga. **470–473.** Callidina elegans.

PLATE XXXV. (Rotatoria).

Figure 474. Hydrias cornigera. **475.** Typhlina viridis. **476–480.** Rotifer vulgaris. **481–484.** Actinurus Neptunius. **485, 486.** Monolabis conica. **487–489.** Philodina aculeata. **490.** P. roseola. **491–494.** Noteus quadricornis. **495–497.** Anuræa Squamula. **498.** A. stipitata. **499–501.** Brachionus polyacanthus. **502–504.** Pterodina Patina. **505.** P. clypeata.

PLATE XXXVI. (Rotatoria).

Figure 1. Melicerta ringens, protruded and fully expanded, with the upper part of its tube at *a*; *b*, one of the tactile tubes; the circular disc at *c* is the pellet-cup; at *m* are the jaws and gizzard (œsophageal head); and below, the stomach; *c*, a much less magnified

specimen, partially protruded from its tube, which is here shown entire, ×300. **2.** Limnias Ceratophylli: the end is protruded beyond the smooth tube or sheath; at *c* is the projecting chin. **3.** Notommata aurita, viewed laterally, contracted: it exhibits the œsophageal head and jaws (*b*), the intestine, the large ovarium, the contractile sac below, the grape-like ganglionic mass in the head (*g*), and the tortuous vessels on each side, running the length of the body. **4.** The same animal extended and rotating; the ear-like ciliated appendage, whence the specific name, is seen on each side of the head. **4** *a*. The ciliated lobes of the rotary organ; *b*, the gizzard, with its jaws; *g*, the cerebral (?) mass; *k*, glands above the stomach; *o*, large matured egg in the ovary. **5.** Notommata aurita, viewed dorsally, the viscera omitted, to show the muscular system; the transverse muscles are seen at *t*, and the longitudinal, crossing them, at *l*; the grape-like ganglionic mass appears connected with special muscles, as also the gizzard, traced in dotted outline, and the telescopic-working tail or foot (*b*); the looped band at the head (*o*) indicates the tubular cavities in the head-mass. **6.** The same animal, showing chiefly its water-vascular system; the large sac near the bottom of its cavity (*v*) is the contractile bladder, from which proceed, on each side, convoluted tubes (tortuous vesicles) furnished with tremulous respiratory tags, as near *a*; the transverse muscular bands seen at *t*. **6***. The dental apparatus of the gizzard as seen in action. **7, 8.** The male of Asplanchna priodonta: **7.** s. v.; **8.** f. v. The cavity is seen occupied chiefly by the large testes in fig. 7; the sperm-duct is represented opening externally at the pointed base. **9.** The female of Asplanchna priodonta: at *a* are the gill-like fissures; a large oral cavity opens into a narrow œsophagus, which ends below in a stomach. One of the strong longitudinal muscles is displayed, also tortuous vessels and ciliated tags, with an ovary. **10, 11.** The jaws of the Asplanchna detached.

PLATE XXXVII. (Rotatoria).

Figure 1. Stephanoceros Eichhornii: *a*, sheath; *b*, pharynx; *c*, proventriculus, or crop; *d*, maxillary head with jaws; *e*, stomach with large glandular cells; *f*, intestine or rectum; *g*, ovary with contained ova (*g* at pedicle indicates the longitudinal muscles in that segment); *tt*, respiratory canal and tags. **2.** Ovary and the enveloping membranous sac, or uterus, extending from it, containing ova in different stages of development: *a*, stroma of ovary with inherent ova; the darker segment probably indicates the position of a winter ovum developing; *b*, ovum dividing; *c*, ovum in which division of yelk has been several times repeated; *d*, an ovum in which the rude outlines of the embryo are distinguishable, the two eyes at *d*, and the sac with the so-called urinary concretion at *k*; *f* points to the uterine or ovarian enveloping membrane. **3.** A very young Stephanoceros. **4.** An embryo of Stephanoceros immediately after its exit from the shell. **5.** An ovum of Lacinularia. **6.** Another ovum of the same, its yelk in process of fission. **7.** A portion of the ovary of the same, with four contained ova. **8.** An ovum of the same, in which division has been repeated several times. **9.** Another ovum, wherein fission has been repeated until the yelk is broken up into a number of cells. **10.** A young embryo of Lacinularia immediately after its exit from the egg. **11.** Another embryo, further developed. **12.** Termination of a tentacular process of Melicerta ringens, showing the piston-like disc, capable of retraction by a muscular band affixed to it, and surmounted by a brush of cilia. **13.** A view of the same process, with the brush of cilia extended. **14.** The same, with the cilia retracted. **15.** An embryo of Melicerta ringens, which has attached itself and has commenced the formation of its case or sheath. **16.** An embryo of the same animal as it appears when swimming freely. **17.** Melicerta ringens, fully developed, with the lobes or petals of its ciliary wreath (*a*) fully expanded; *b*, uncini; *c*, ciliated process, representing a fifth lobe; *d d*, tentacula, as shown in figs. 12, 13, 14; *e*, jaws; *g*, lower or second stomach; *h*, intestine; *k*, coloured globules; *l*, suctorial end of pseudopodium; *m*, muscles; *n*, gland; *o*, ovum. **18.** Two muscular fasciculi, showing transverse markings. **19.** Lacinularia socialis: *a*, pharynx; *b*, maxillæ, or jaws; *c*, muscular crop; *d*, stomach; *e*, lower segment of stomach, terminating in a narrow rectum and anus at *i f*; *g*, a glandular (?) process; *h*, ovary; *i*, respiratory canal; *k*, pedicle (Huxley). **20.** Maxillæ of Lacinularia socialis. **21.** Winter ovum in act of division. **22.** Segmentation of a portion of the ovary, of a different character from the rest, in process of forming a winter ovum. **23.** Maxillæ of Melicerta ringens, in bulb. **24.** Winter ovum of Lacinularia. **25.** A portion of ovary of Notommata centrura: *a*, the homogeneous germinal spot; *b*, the clear areola around it; *c*, yelk-matter. **26.** Maxillæ of Melicerta ringens. **27.** Winter ovum of Asplanchna Sieboldii treated with solution of soda. **28.** Winter ovum in its natural state. **29.** Male of Asplanchna Sieboldii, viewed from the abdominal surface: *a a*, the anterior short arms; *b b*, the posterior longer arms; *c*, testis, or spermatic sac, filled with spermatozoa; *d*, water-vascular canal. **30** *a*, *b*, *c*, *d*, *e*, *f*. The corpuscles of the preceding

at *c* represent the earliest stage of the spermatic particles; those at *a* the mature, including the rod-like particles. **31.** The maxillæ of Asplanchna Sieboldii; the striated muscular bands moving them are very distinct. **32.** The female of Asplanchna Sieboldii: *a*, pharynx; *b*, cells of stomach; *c*, horseshoe-shaped ovary; *d*, saccular or uterine portion of oviduct, or ovarian sac, with contained mature ovum; *e*, contractile vesicle; *f*, tags of water-vascular canal; *k*, ditto; *g*, muscular (?) cushion within ciliary wreath supporting spines.

PLATE XXXVIII. (Rotatoria).

Figure 1. Rotifer inflatus, body extended; rotary apparatus withdrawn. **2.** The same Rotifer, with the horn-like appendages of its rotary apparatus expanded. **3.** The same Rotifer, strongly contracted into a globular form. **4.** Philodina erythrophthalma, in a contracted condition, as found when dried. **5.** Euchlanis triquetra, viewed on the under side: *a* points to the lining membrane of the lorica in which the muscles are inserted; *b*, muscles; *c*, ganglionic enlargement; *d*, respiratory tube; *e*, areolar tissue of head; *f*, œsophagus, or tube between maxillary head and stomach. **6.** Anuræa heptodon. **7.** Brachionus rubens, the young just emerged from the shell. **8–10.** B. Bakeri: **8.** Young from the egg; **9.** Summer egg; **10.** Winter egg. **11.** Notommata centrura, a portion of the respiratory tube, with the ciliary tags within. **12.** Termination of a tag, with the cilium within. **13.** A portion of a water-vascular canal, with ciliated tags of Asplanchna Sieboldii. **14.** Diagram of head of Brachionus polyacanthus, viewed from the mouth side. **15.** Diagram of head of the same, viewed from above. **16.** A portion of the cerebral ganglion and of the nerves proceeding from it, and the eye consisting of two portions. **17.** Eye of Brachionus Bakeri, detached. **18.** Eye of Euchlanis unisetata. **19.** Eye of Caligus. **20.** Diagram of head (trochal disc) of Philodina. **21.** Diagram of same, viewed from the mouth side. **22.** Rattulus carinatus. **23, 24.** Salpina spinigera. **25.** Noteus quadricornis, dorsal view: *a*, maxillæ; *c*, anterior spinous cornu of lorica; *c c*, posterior cornu; *d*, ovary; *f*, vesicle of water-vascular system; *e*, canal of ditto; *h*, stomach; *i*, muscles. **26.** Notommata centrura, dorsal view, surrounded by a mucous external envelope, and lined by a subtegumentary lamina or dermis: *b*, antenna; *c*, glandular sac around œsophagus; *d*, elongated process of rotary organ, called the under lip; *e*, tags of respiratory canal; *f*, stomach, with large glandular cells of its wall; *g*, intestine; *h*, pancreatic glands; *i*, vesicle of water-vascular or respiratory system; *k*, cerebrum; *l*, canal of respiratory tube surrounded by a granular coat; *o*, ovary; *p*, ovum; *n*, muscular bands; *q*, chitinous lining of œsophagus; *r*, transverse muscles. **27.** Brachionus Bakeri: *a*, lorica or carapace; *b*, posterior horns; *c*, anterior horns; *d*, lobes of trochal disc; *e*, siphon or antenna; *f*, gastric canal or œsophagus; *g*, convoluted respiratory tube; *l*, pancreatic glands. **28.** Asplanchna priodonta: *a*, longitudinal muscles; *b*, œsophagus; *c*, stomach; *d*, ovary; *e*, pharynx. **29.** Pterodina Patina, foot not shown: *a c*, convolutions of respiratory canal; *b*, longitudinal striated muscles. **30.** Polyarthra platyptera: *a*, ciliated tubercular processes of head; *c*, compound feathery processes used as locomotive organs; *d*, mature ovum adherent externally; *m*, striated longitudinal muscles. **31, 32.** Polychætus subquadratus. **33.** Maxillæ of Notommata vermicularis, with the red eye, consisting of two portions (*a*). **34.** Maxillæ of Hydatina senta. **35.** Maxillæ of Albertia vermicularis. **36.** Albertia vermicularis, ×200. (Figured after Dujardin, Huxley, Leydig, and Perty.)

PLATE XXXIX. (Rotatoria).

Figures 1–3. Lindia torulosa: **1.** Rotary organ retracted; **2.** Dental apparatus of ditto; **3.** Rotary organ expanded. **4–7.** Euchlanis dilatata: **4.** Female, lying on its back, abdomen upwards; **5.** Male, lying on its back; **6.** The granular heap from a young male; **7.** Male, lying on its abdomen. **8, 9.** Notommata parasita (Ehr.): **8.** Male; **9.** Female. **10–20.** Brachionus urceolaris: **10.** A summer ovum in the act of fission; **11.** The embryo escaping from a summer egg, with rupture of shell; **12.** A young male after its escape from the egg; **13.** A male escaping from the egg; **14.** A young male, older than fig. **12**; **15.** Female, rotary organ fully expanded; **16.** Female, with four male eggs in different stages of development attached; **17.** Female, rotary organ retracted, tentacular process (calcar) protruded; **18.** Female, lateral view; **19.** Maxillary bulb (mastax), with teeth in position; **20.** A winter, ephippial, or lasting ovum. **21–24.** Brachionus militaris: **21.** Female, lying on its back; **22.** Female, lying on its abdomen; **23.** A winter ovum; **24.** A male ovum. (Cohn.)

PLATE XL. (ROTATORIA).

Figure 1. Hydatina senta, female, lateral view: *a*, dorsum and oral cavity, extending to an apex at *b*; *c*, mastax with maxillæ; *d*, canal between mastax and stomach; *f*, cloaca orifice; *g*, vesicle; *h*, ovary; *i*, coils of respiratory tube; *k*, cerebral ganglion; *l*, ciliated tactile fossa; *m*, longitudinal muscles. **2.** Enteroplea Hydatina, the male of Hydatina senta. **3.** Ova in an immature state, as found in the unimpregnated ovary of Hydatina senta: *a*, germinal spot; *b*, germinal vesicle; *c*, membrane of ovum occupied with granular yelk-matter. **4.** The lining membrane of stomach of Hydatina senta, everted, showing cilia. **5.** Vibratile tag, supported on its pedicle, attached to the respiratory canal. **6.** The male sexual organs (of Enteroplea Hydatina) detached, and highly magnified: *a*, penis; *b*, gland surrounding its bag; *c*, vesicles with granules; *d*, fold of integument surrounding penis when retracted. **7.** Detached spermatozoa. **8.** Stephanops muticus, seen from beneath. **9.** Same, side view. **10.** Another view from beneath, or the ventral surface. **11.** Brachionus Dorcas, female, newly born. **12.** Same, male, newly born (Gosse). **13.** B. Mülleri (male): *a*, head mass; *b*, eye; *c*, muscles; *d*, posterior mass; *e*, sperm-sac; *f*, urinary concretion; *g*, foot. **14.** B. Pala, male, newly born. **15.** Same, male egg, nearly mature. **16.** B. Bakeri. **17.** Sacculus viridis, male, newly born. **18.** Same, female, with male ova attached. **19.** Brachionus angularis, male. **20.** B. urceolaris, mastax and dental apparatus, ventral aspect: *a*, mastax; *b*, malleus; *c*, manubrium; *d*, articulation; *e*, uncus; *f*, incus; *g*, ramus; *h*, fulcrum; *i*, muscle connecting the uncus with the ramus; *j*, muscle for extending the malleus; *l*, muscle for throwing in the manubrium; *k*, muscle for bending the malleus; *m*, buccal funnel; *n*, salivary glands; *o*, alula. [These letters have the same signification where met with in the following figures after Gosse:] **21–23.** B. urceolaris: **21.** Jaws viewed nearly from above; **22.** Dental apparatus, lateral aspect; **23.** Buccal funnel, salivary glands, mastax, and dental apparatus, dorsal aspect. **24.** Diglena forcipata, jaws closed, ventral aspect. **25.** Floscularia ornata, jaws, dorsal aspect. **26.** The same, frontal aspect. **27.** Stephanoceros Eichhornii, jaws, dorsal aspect. **28.** Same, uncus, oblique aspect.

INDEX

TO

THE DESCRIPTION OF THE FAMILIES AND GENERA OF INFUSORIA.

THE END.

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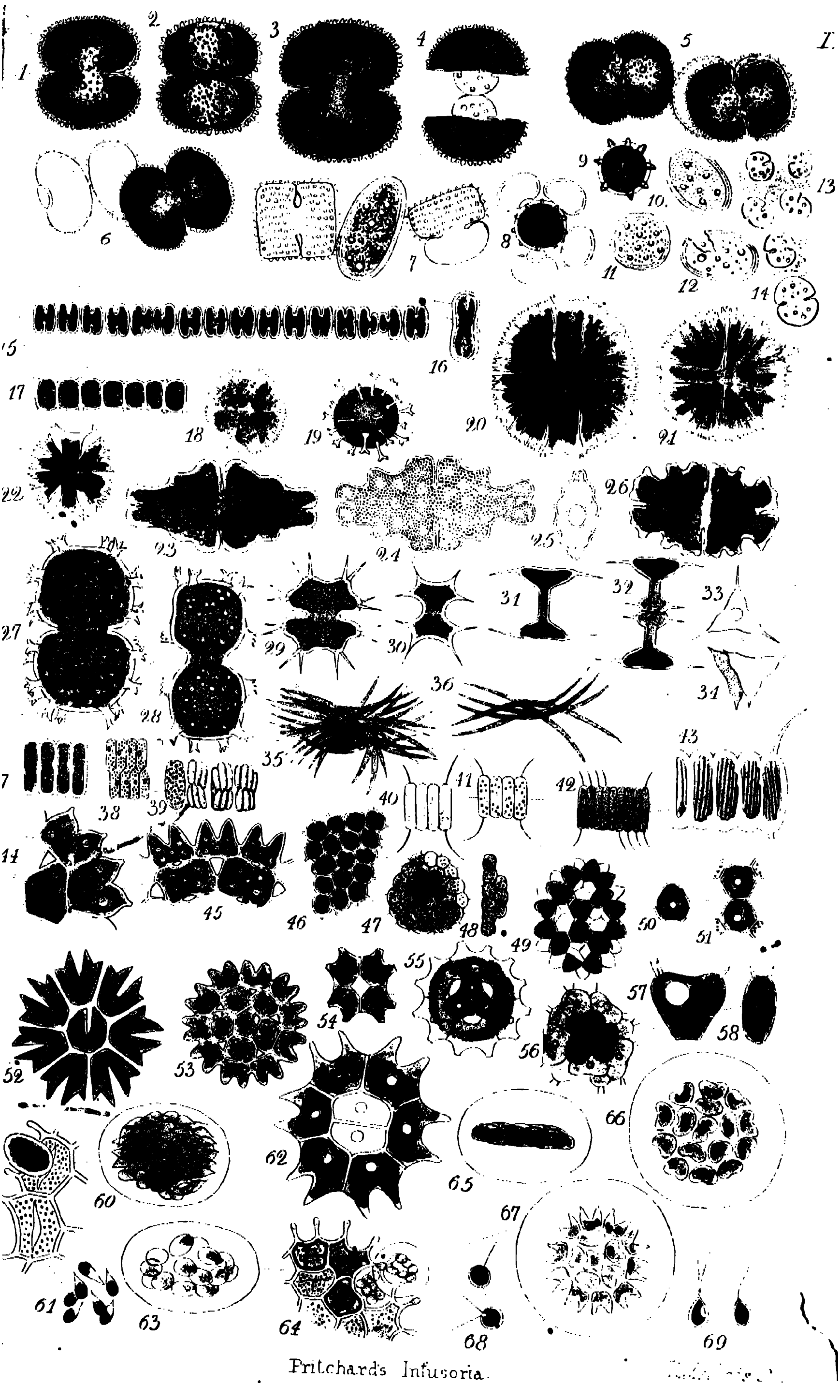
I.



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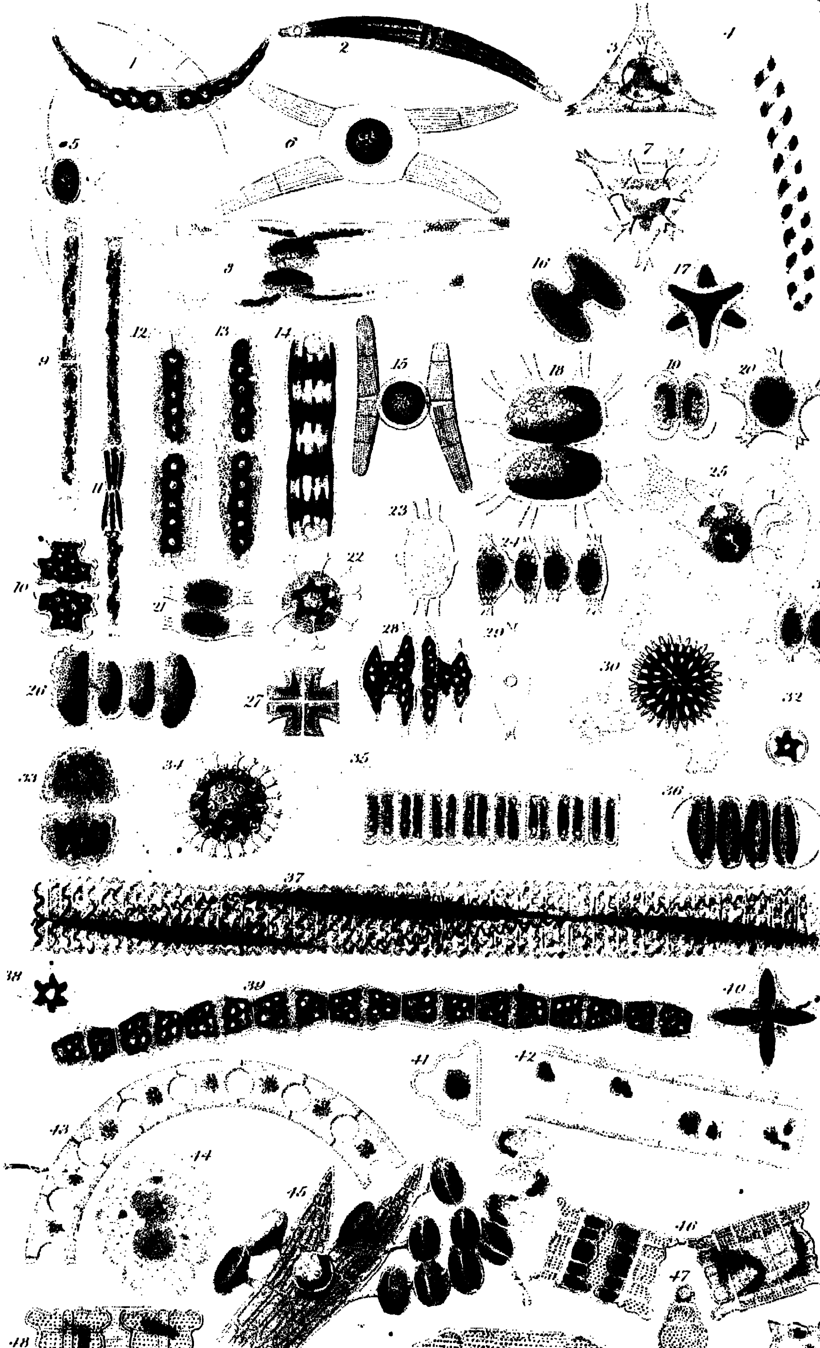

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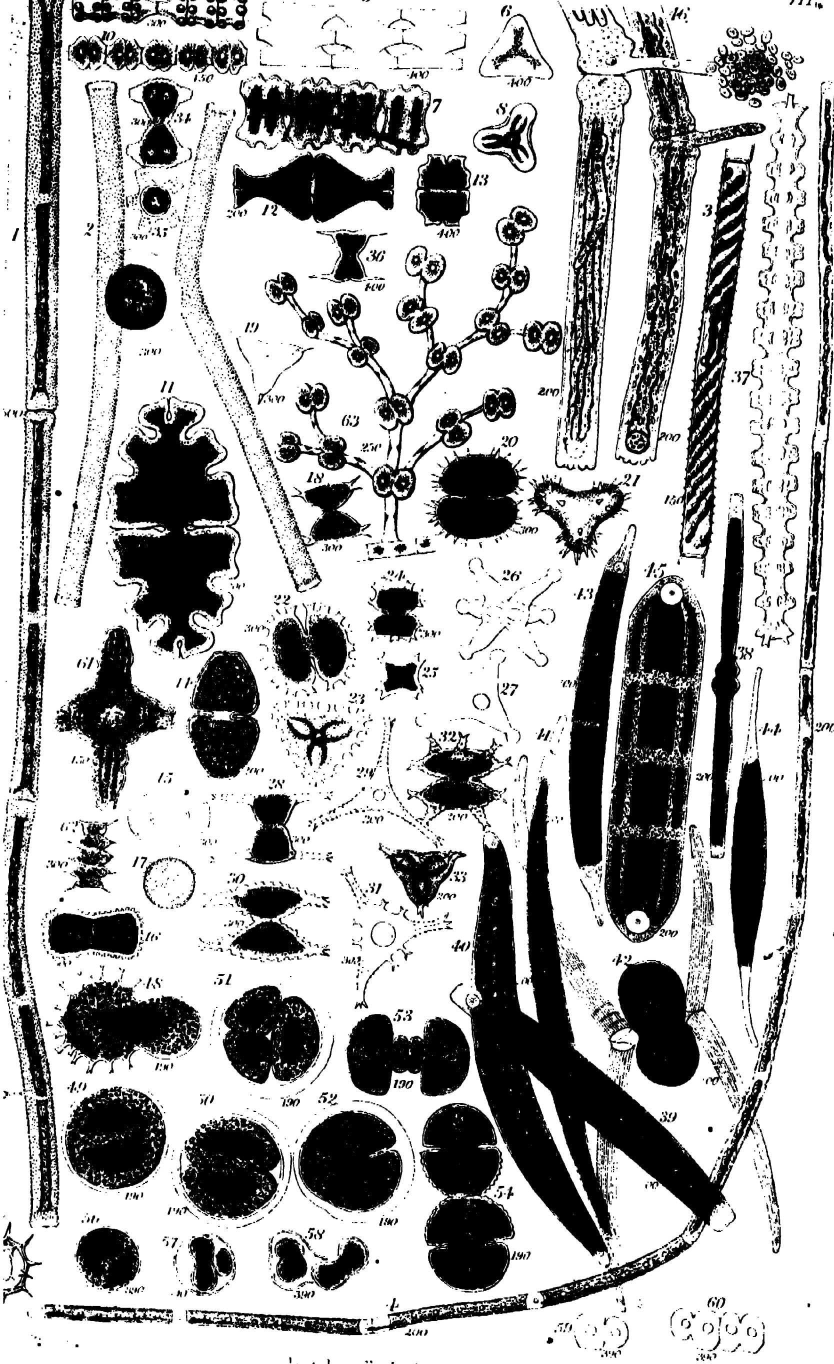

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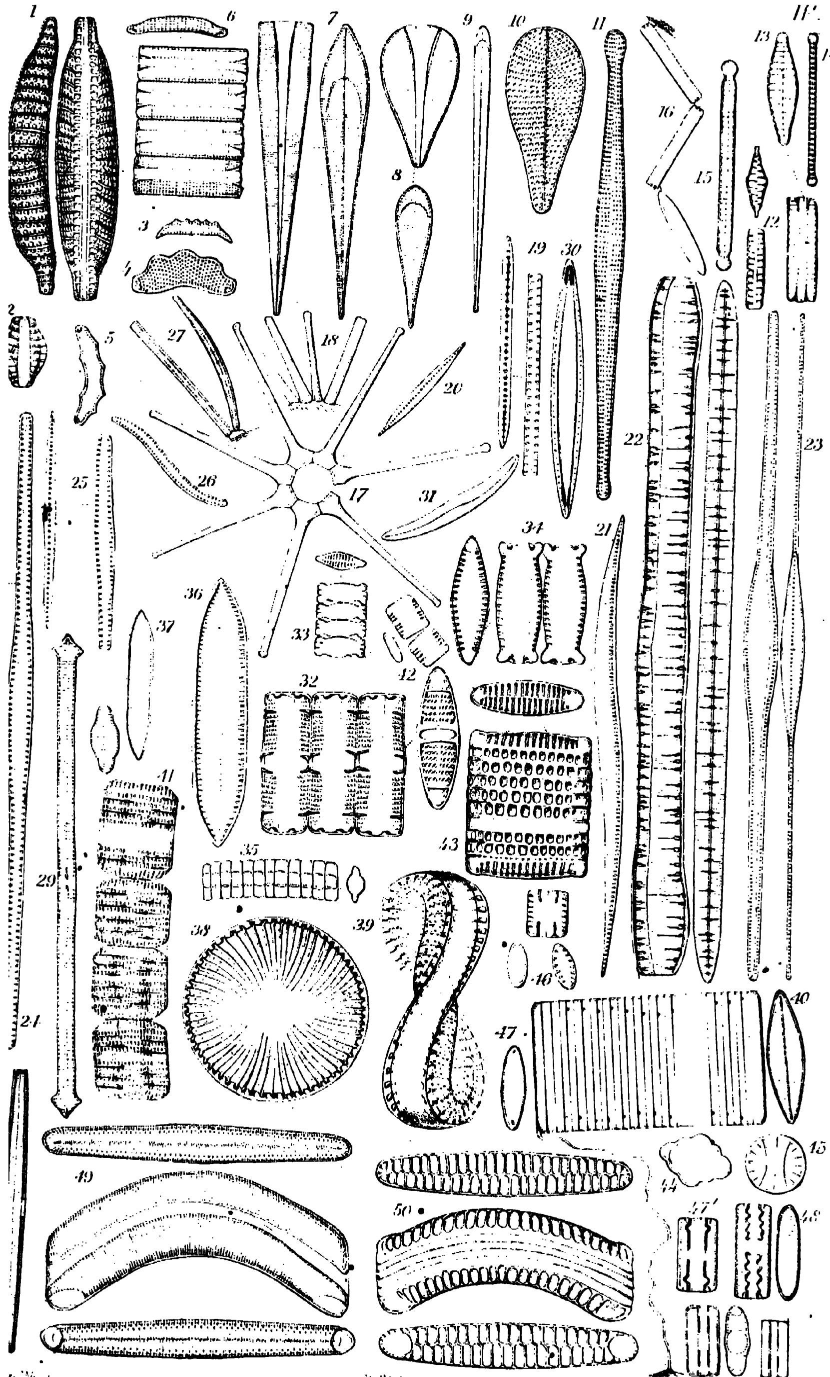

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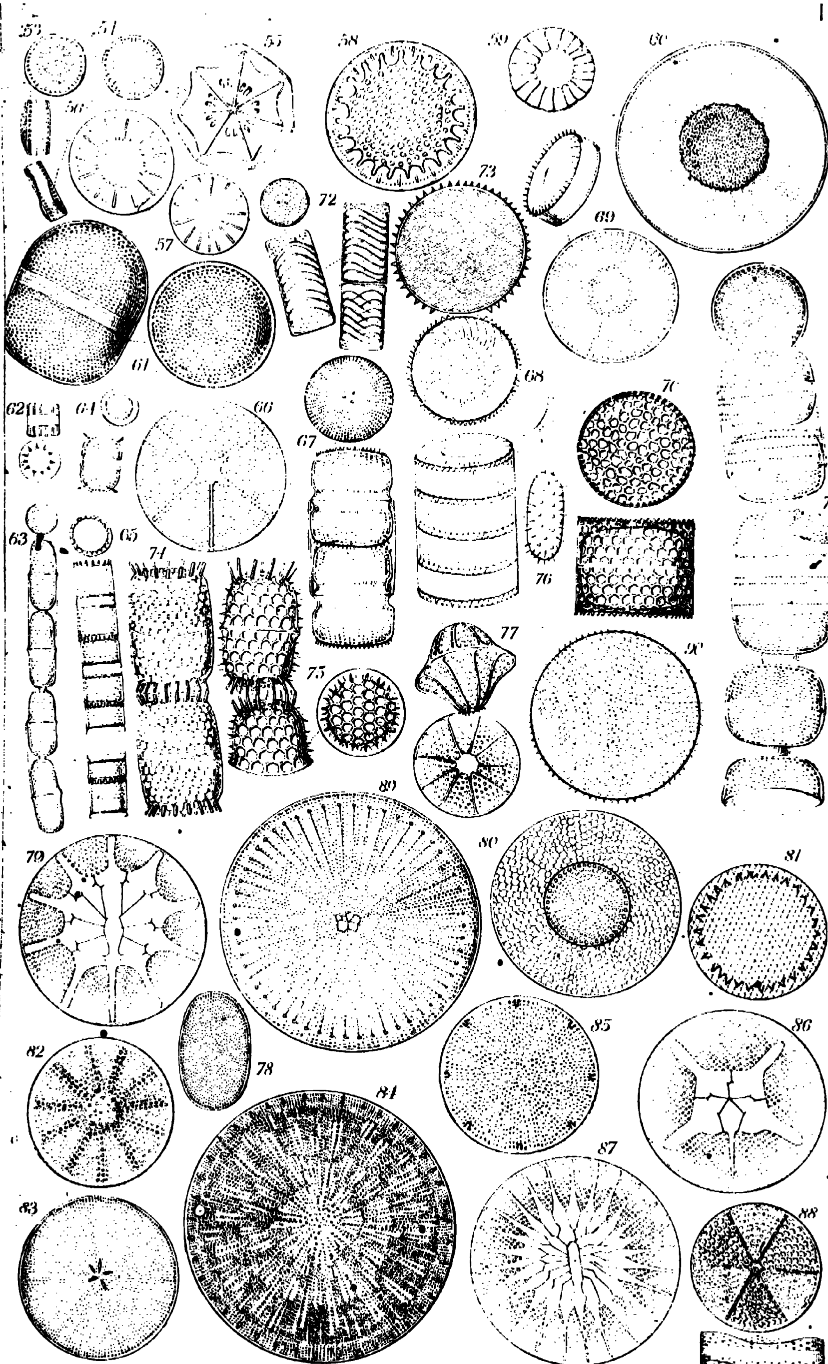

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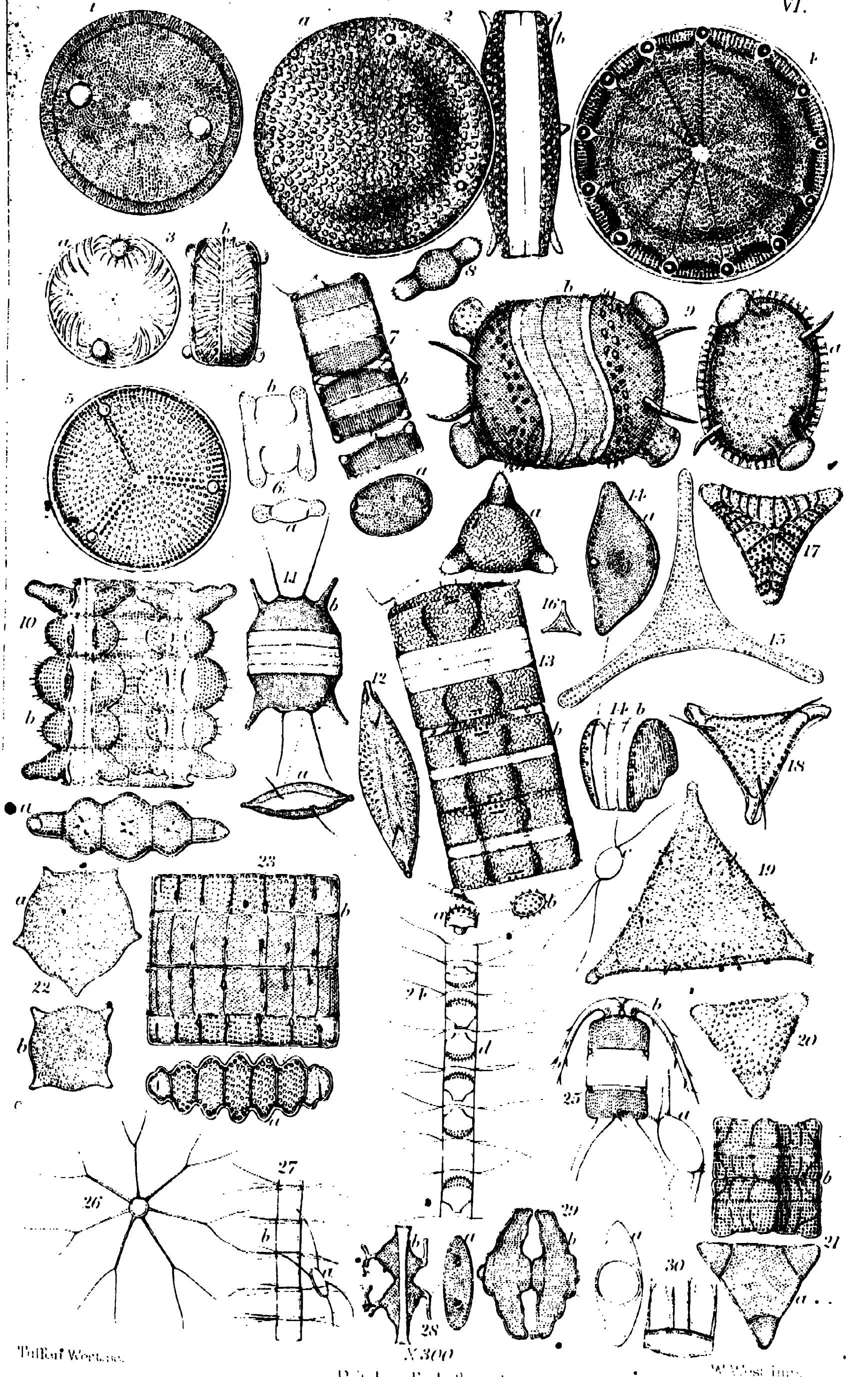

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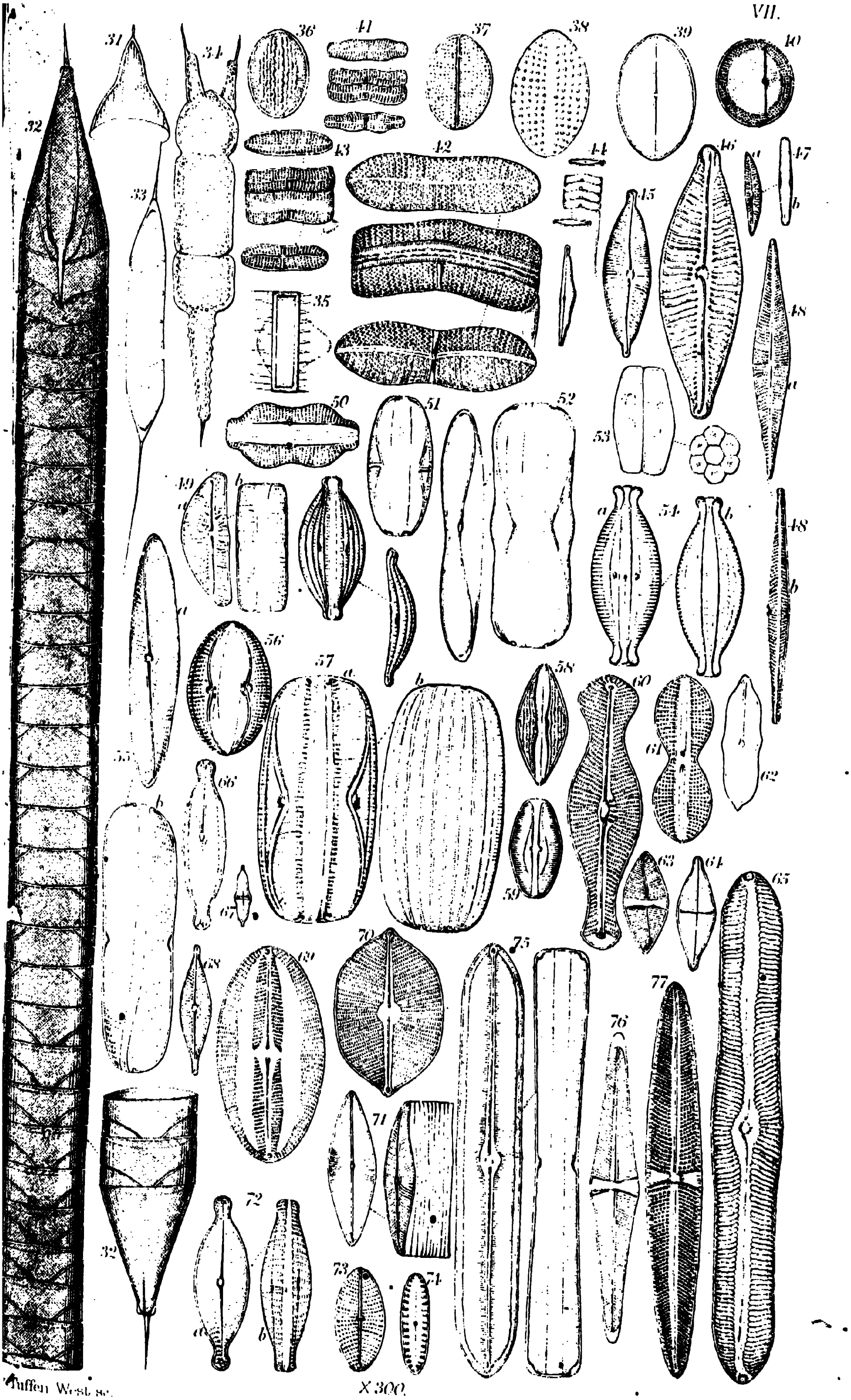

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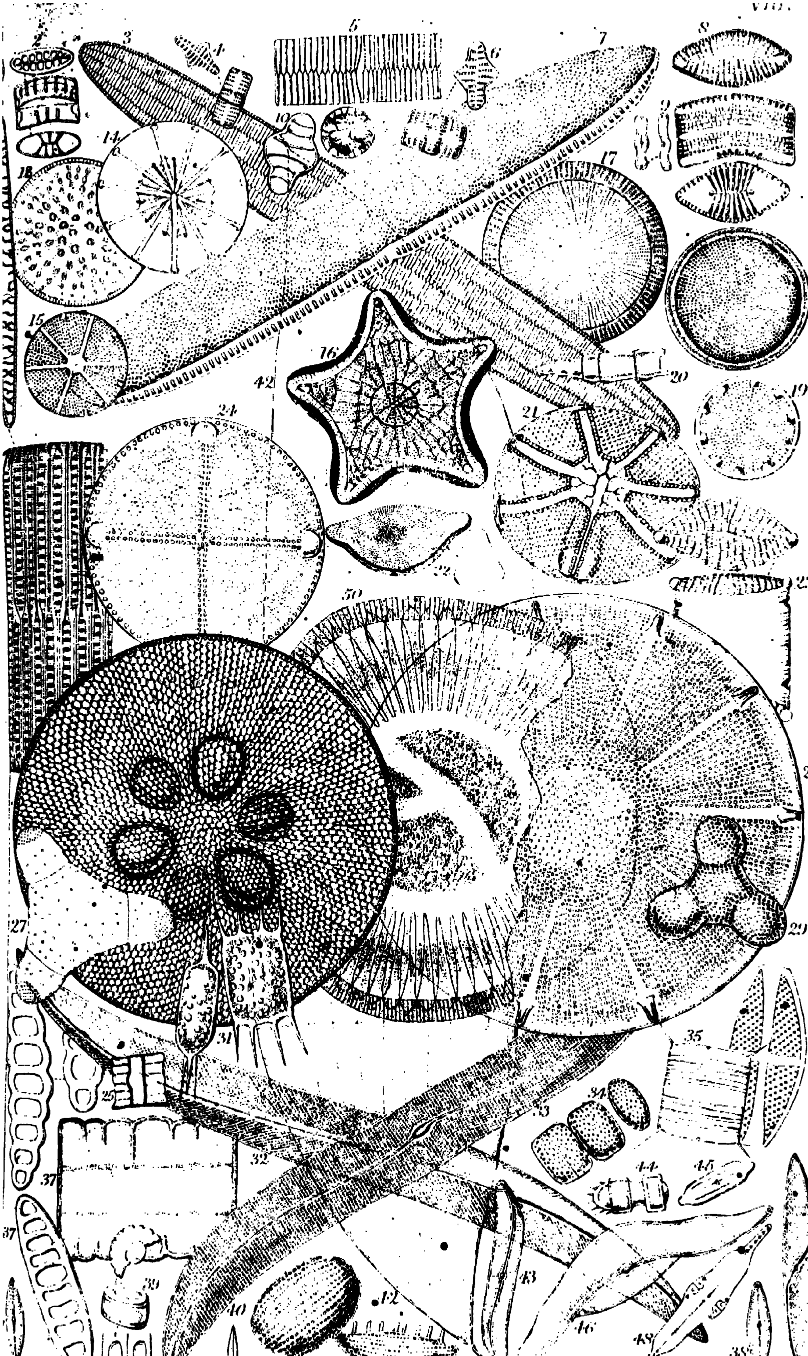

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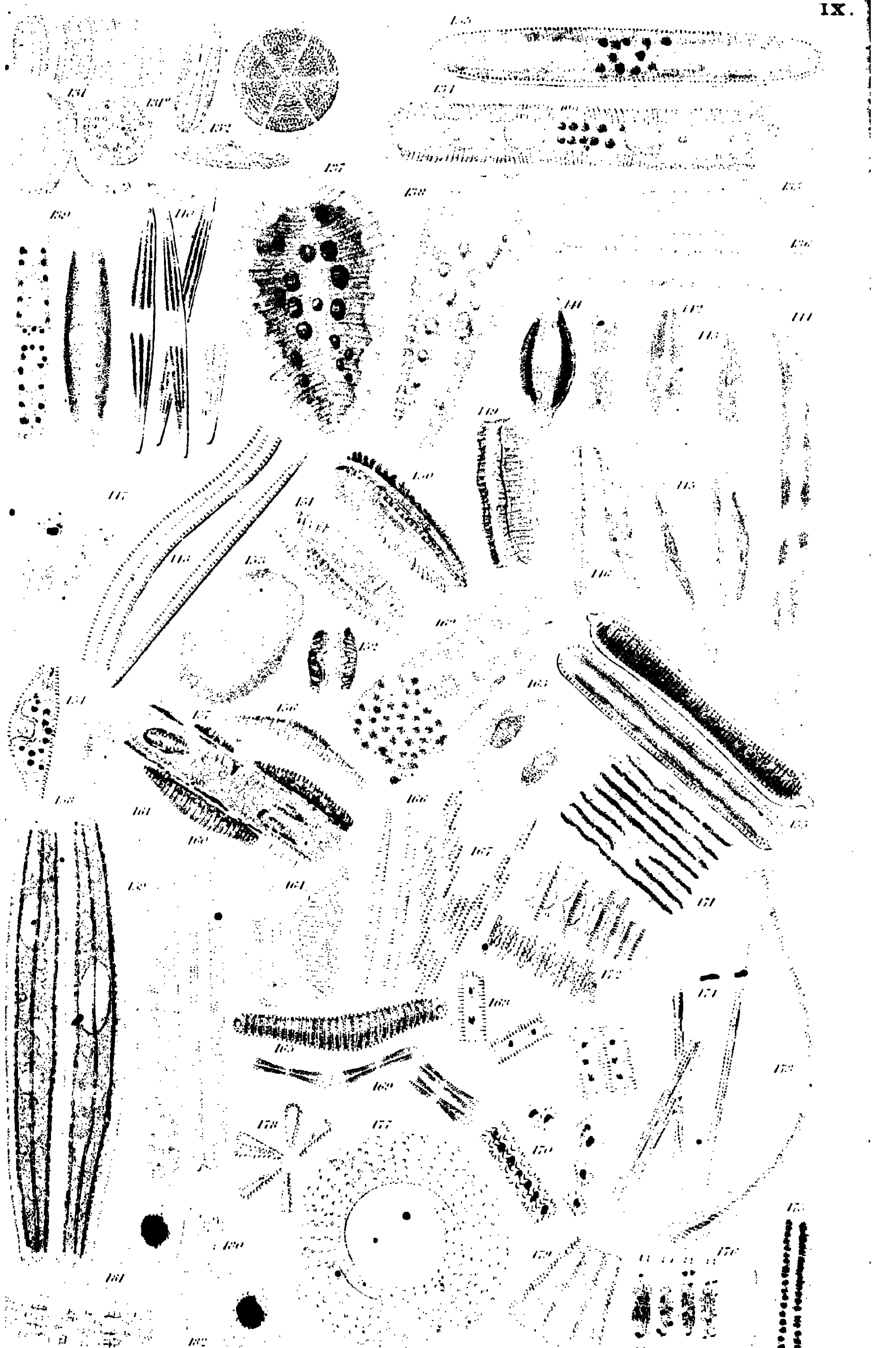

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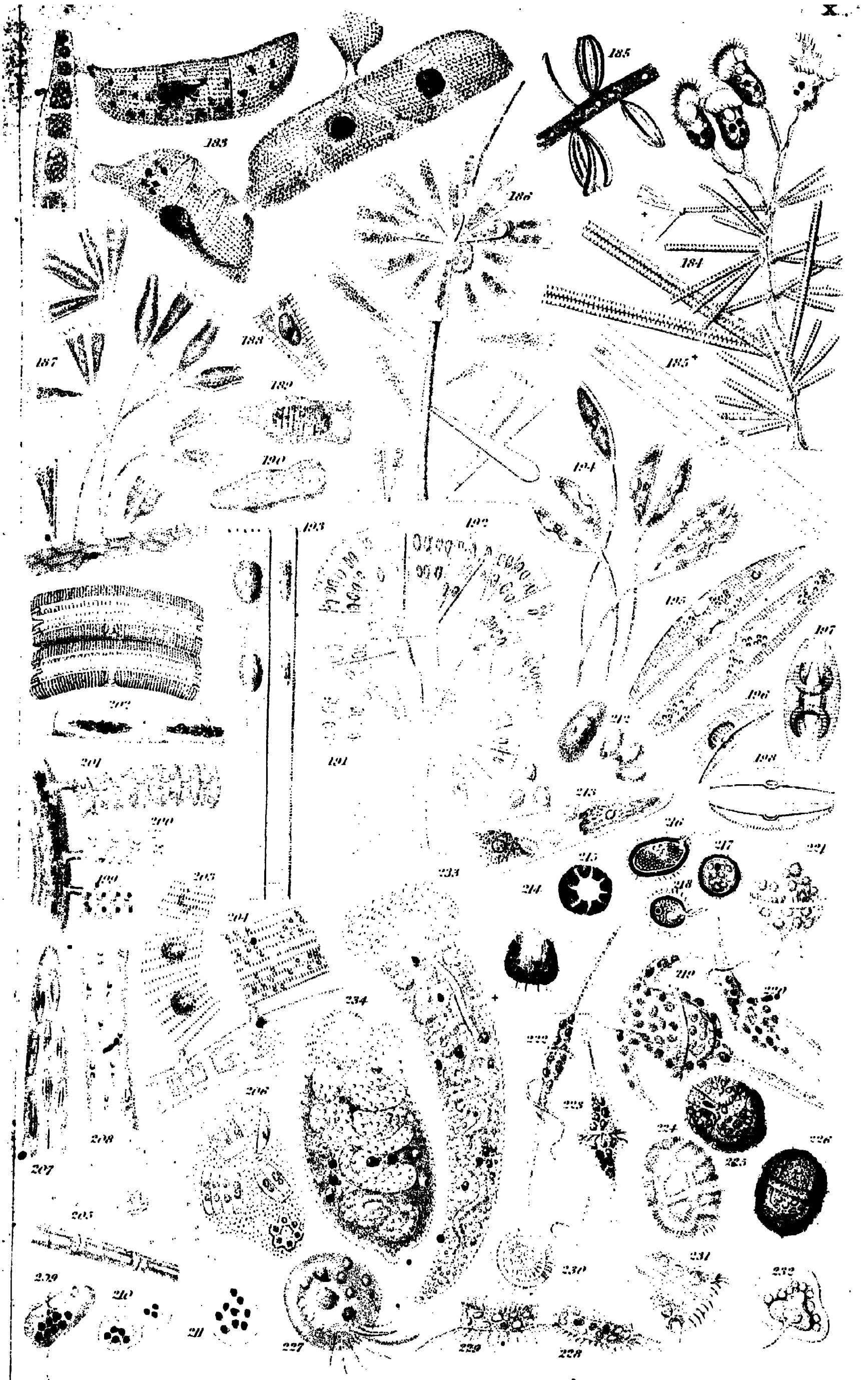

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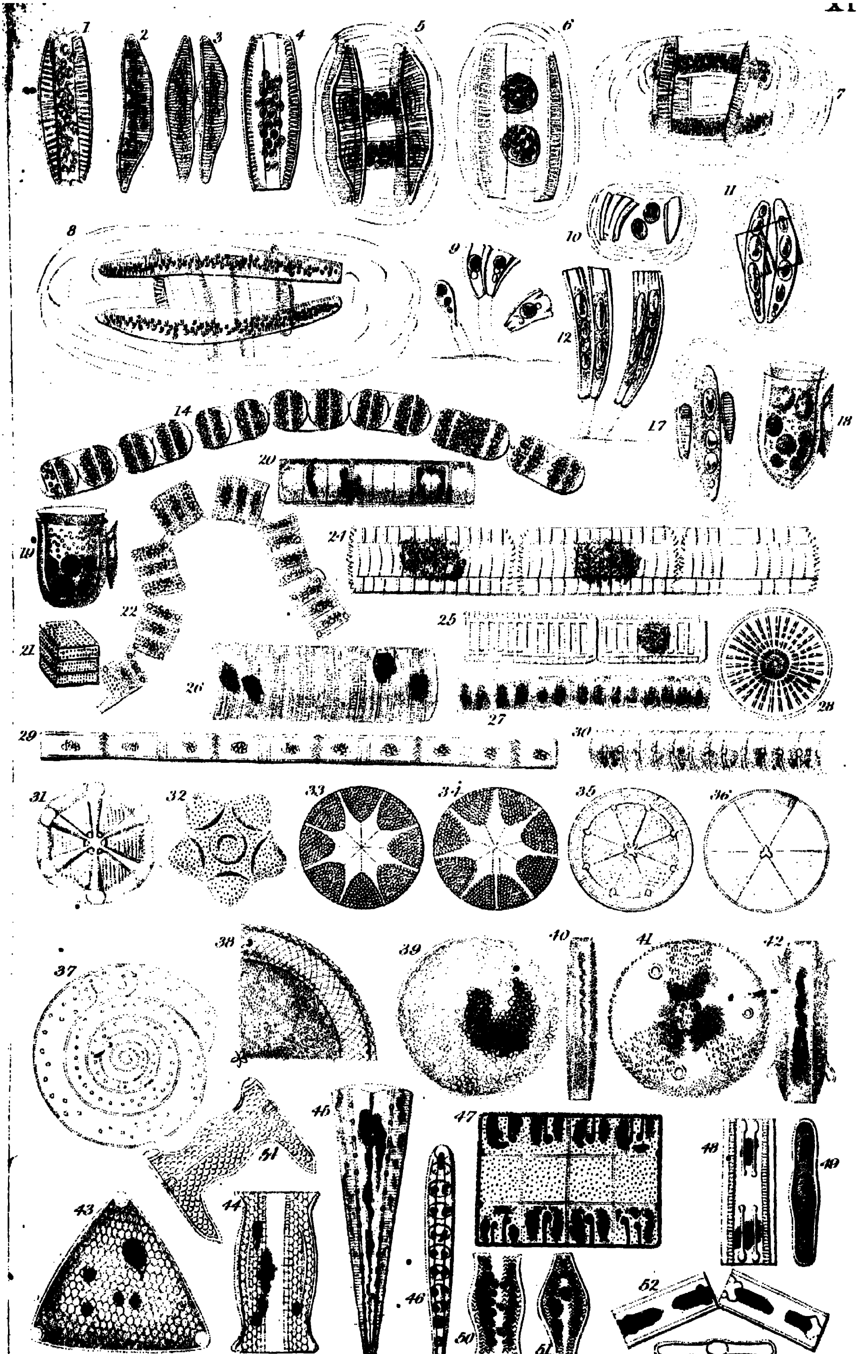

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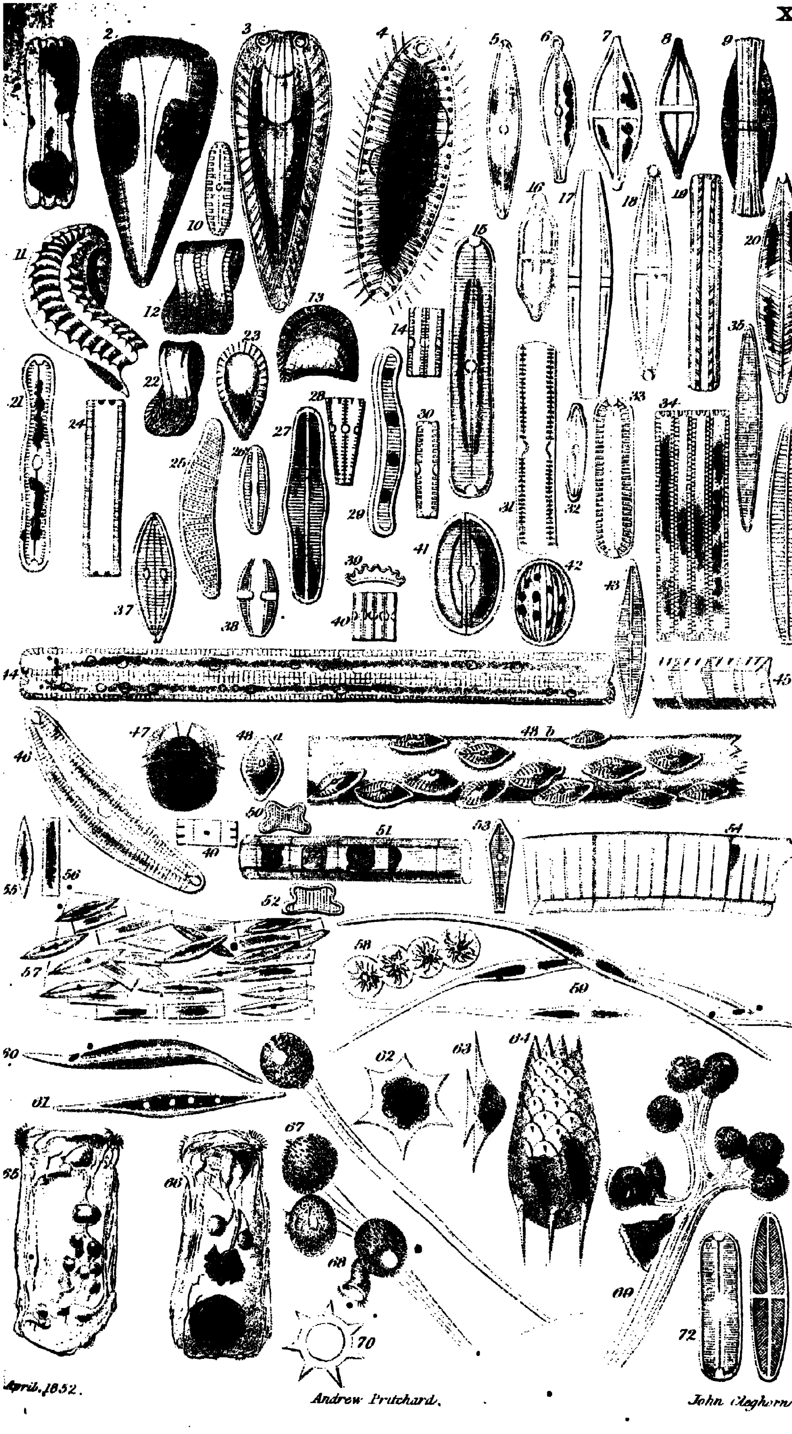

April. 1852. Andrew Pritchard. John Cleghorn.

XIII.

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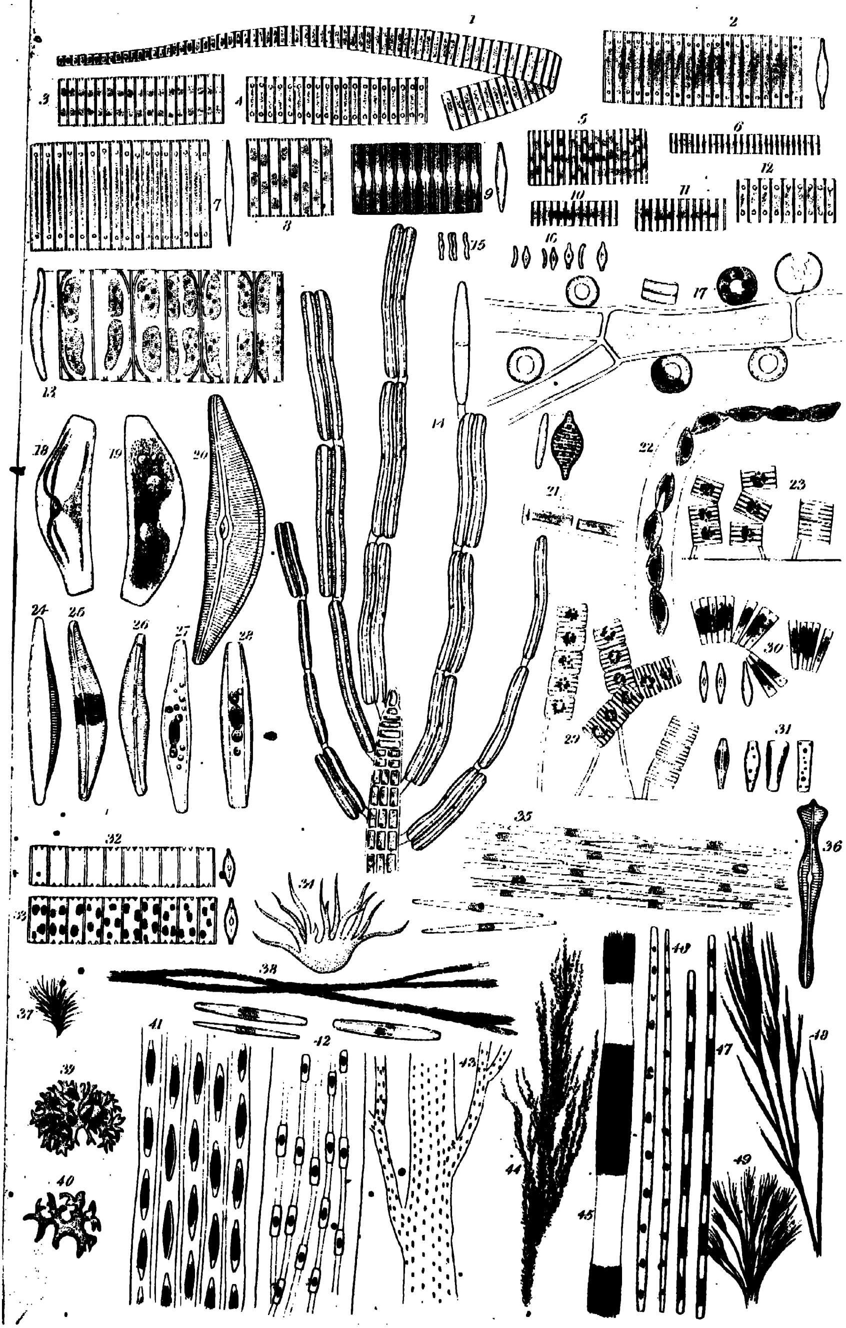

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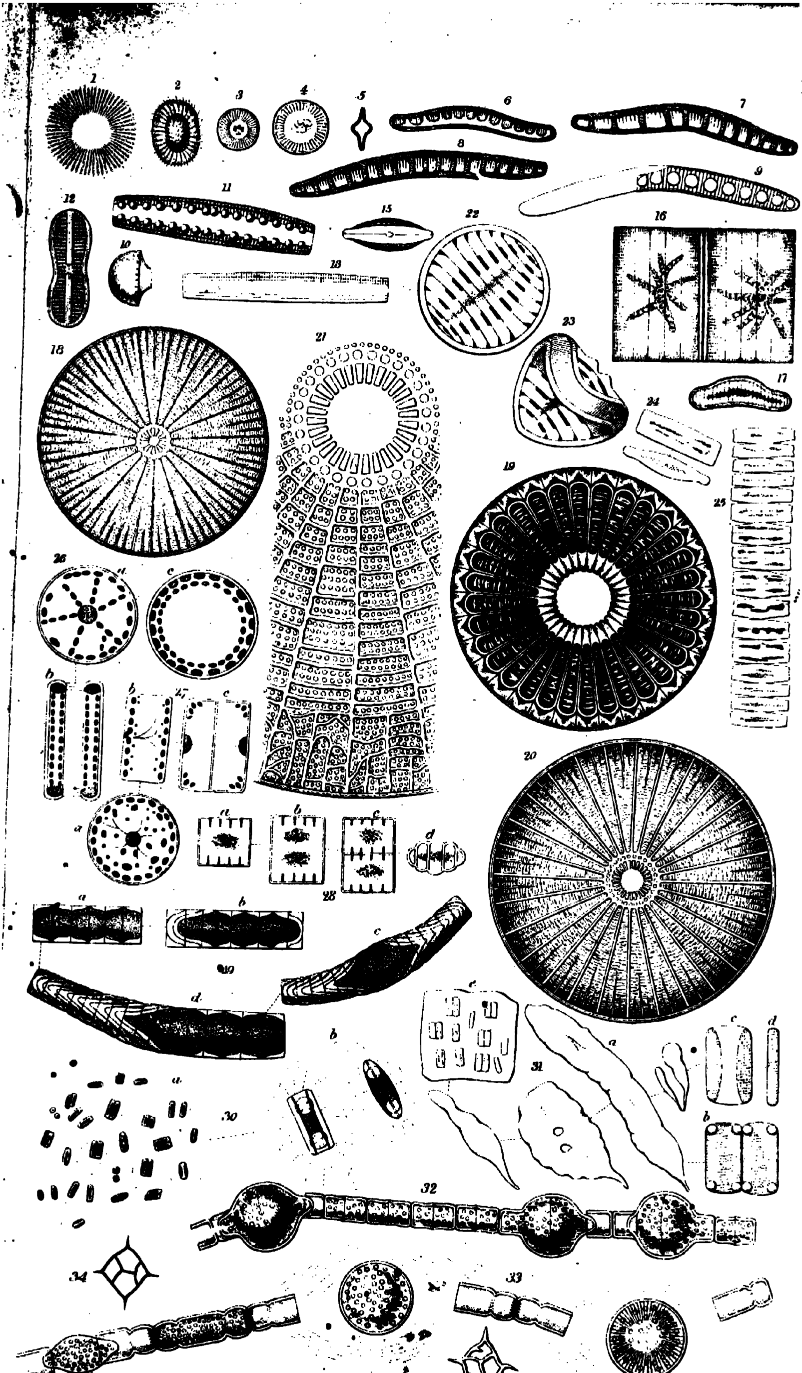

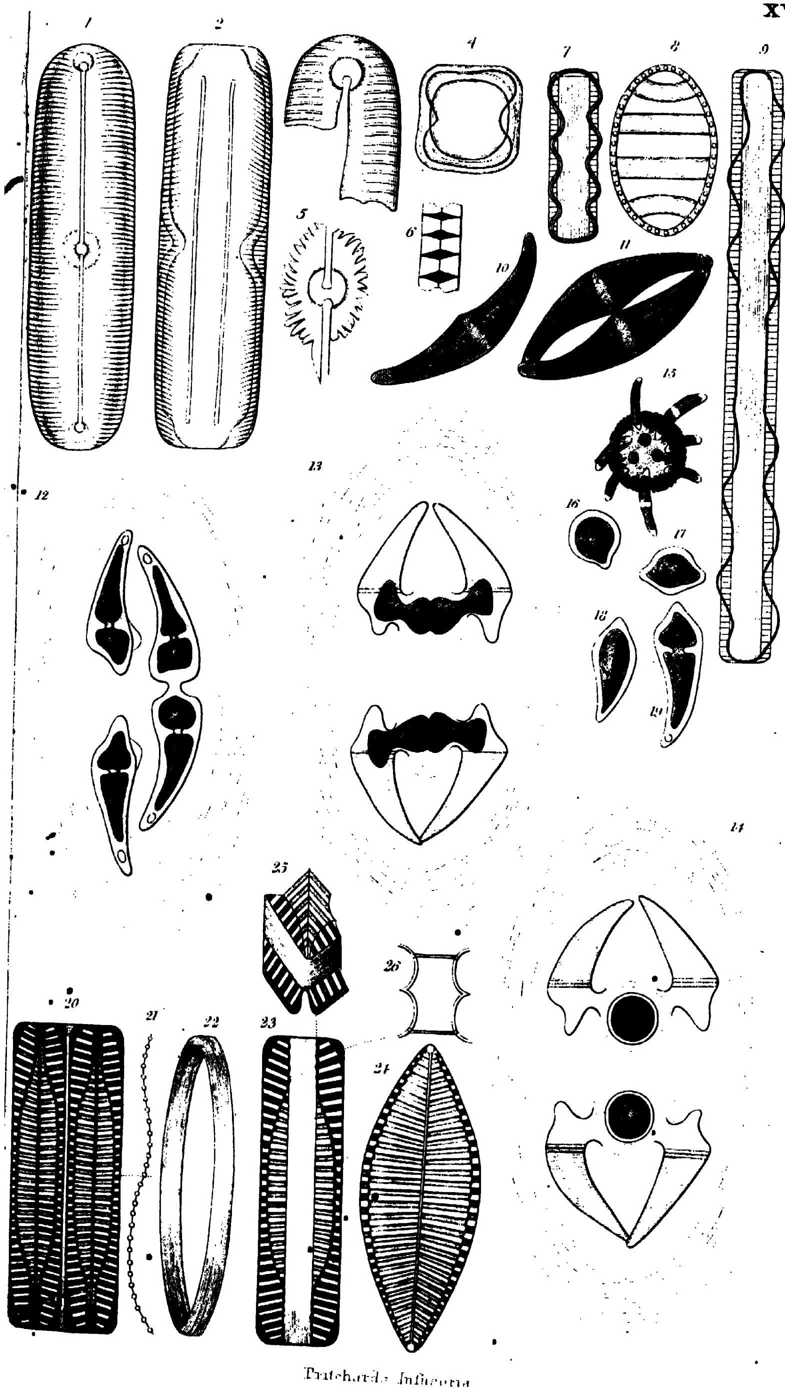

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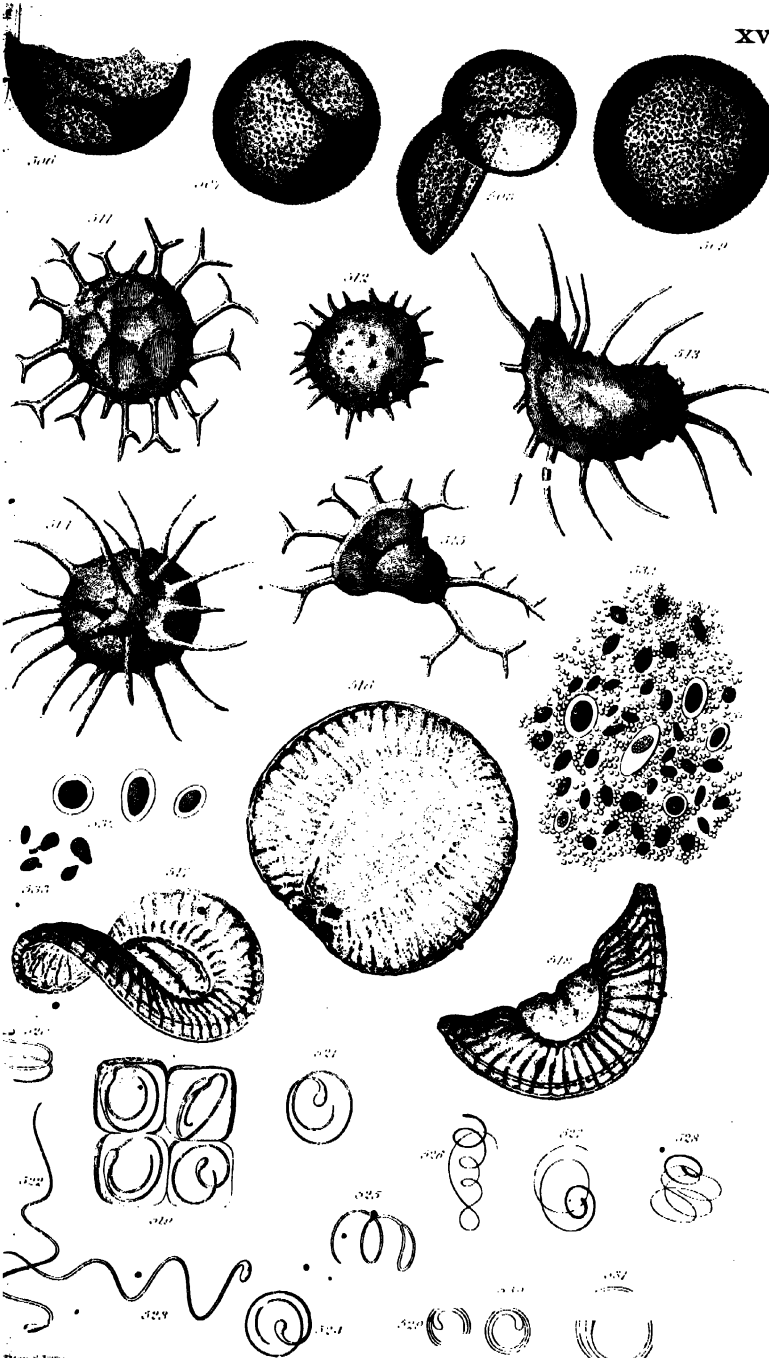

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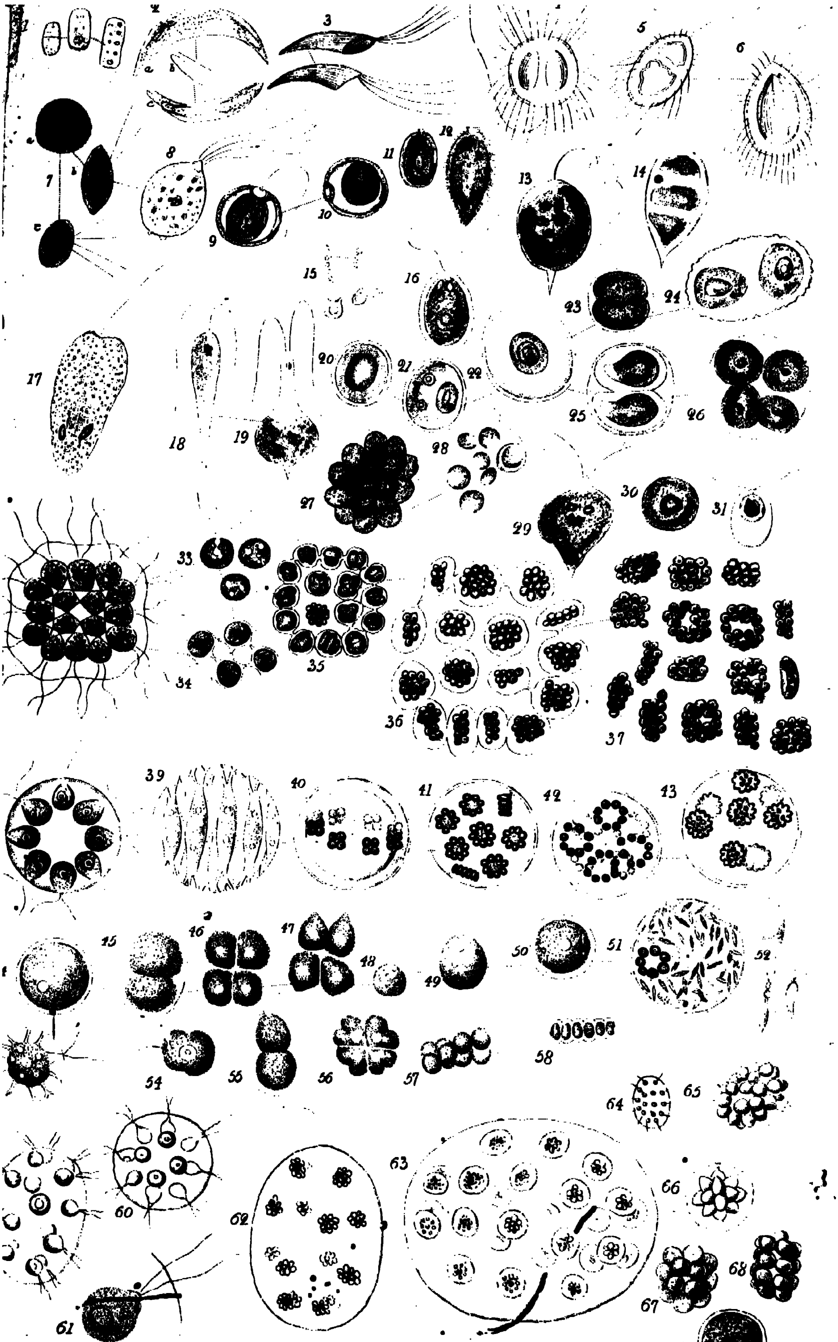

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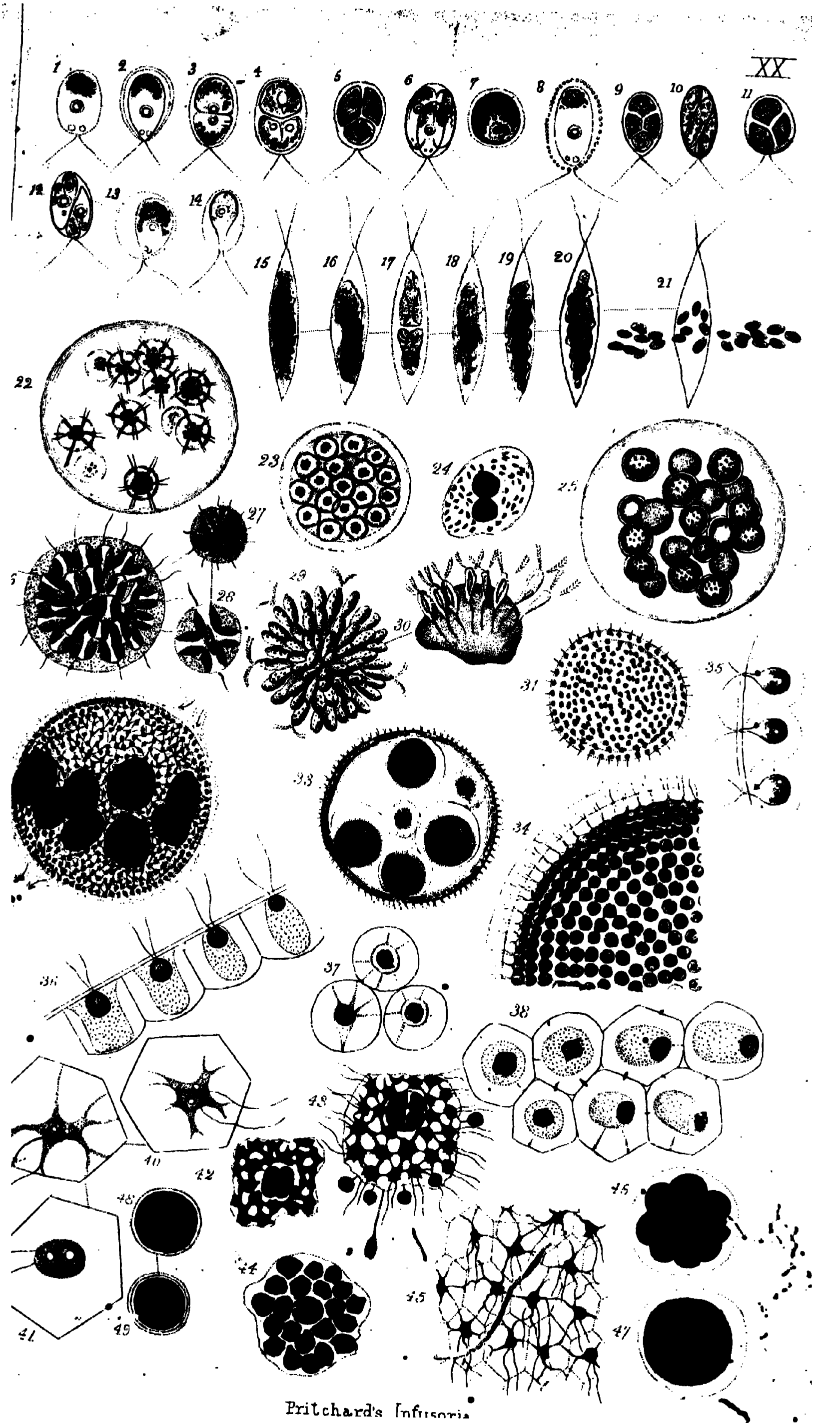
XX



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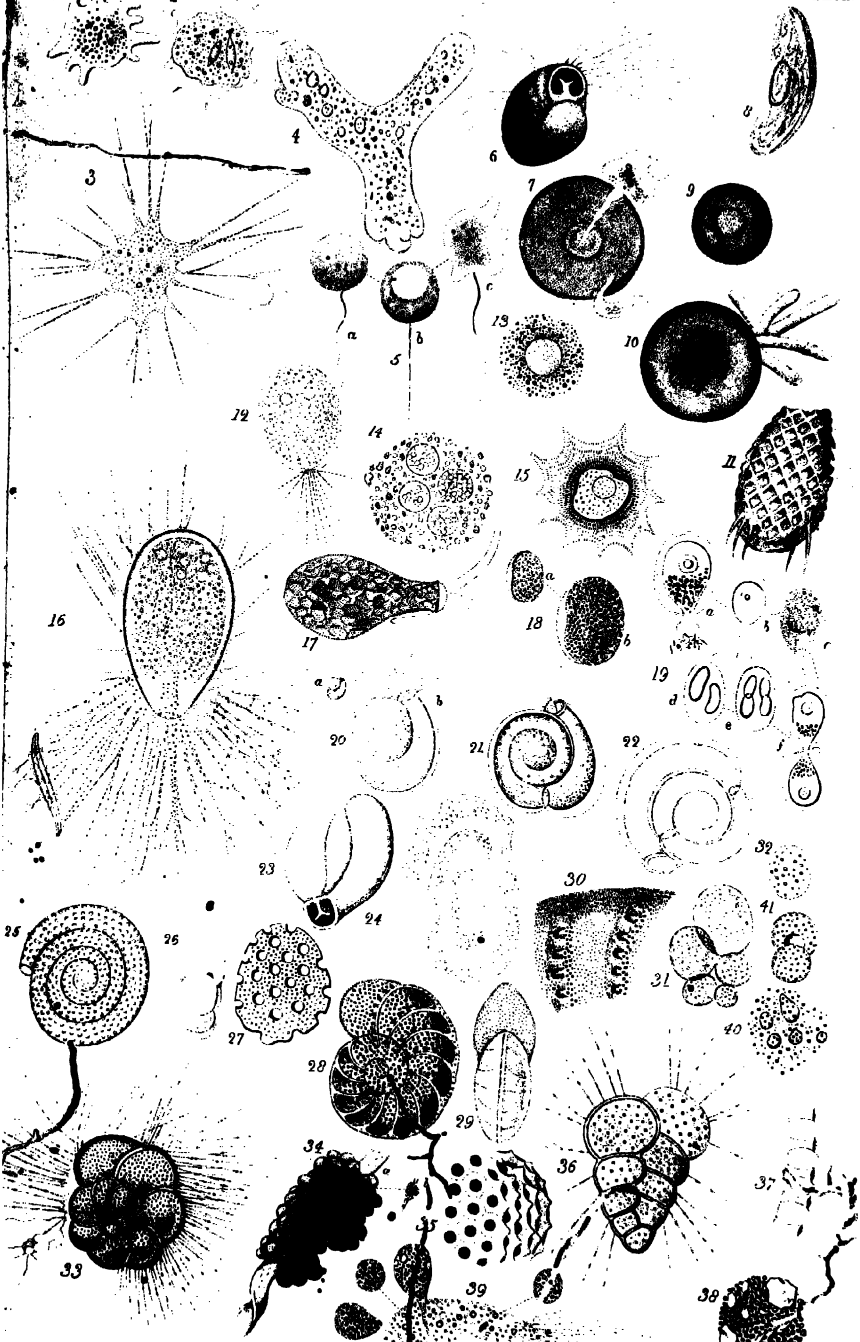

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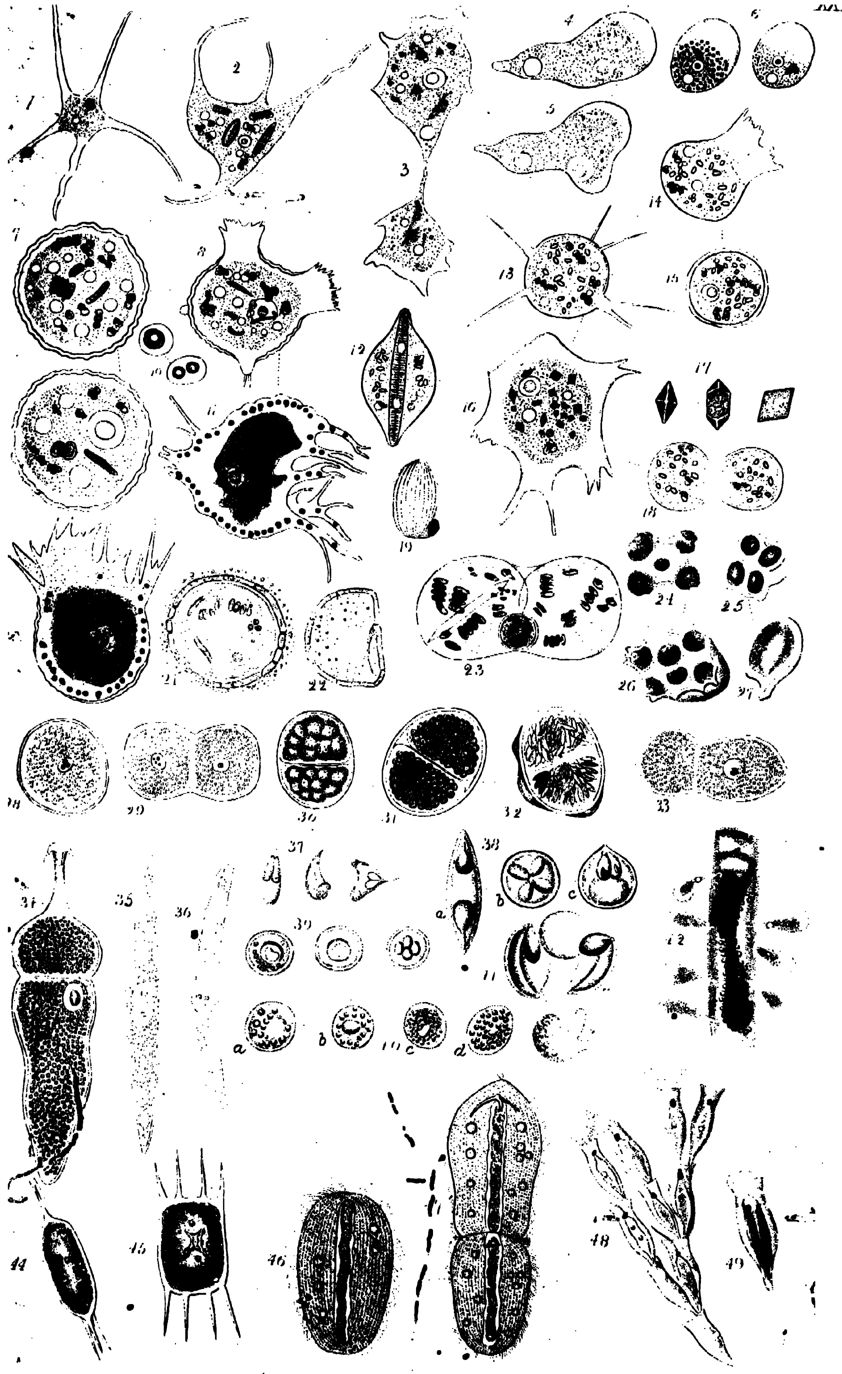

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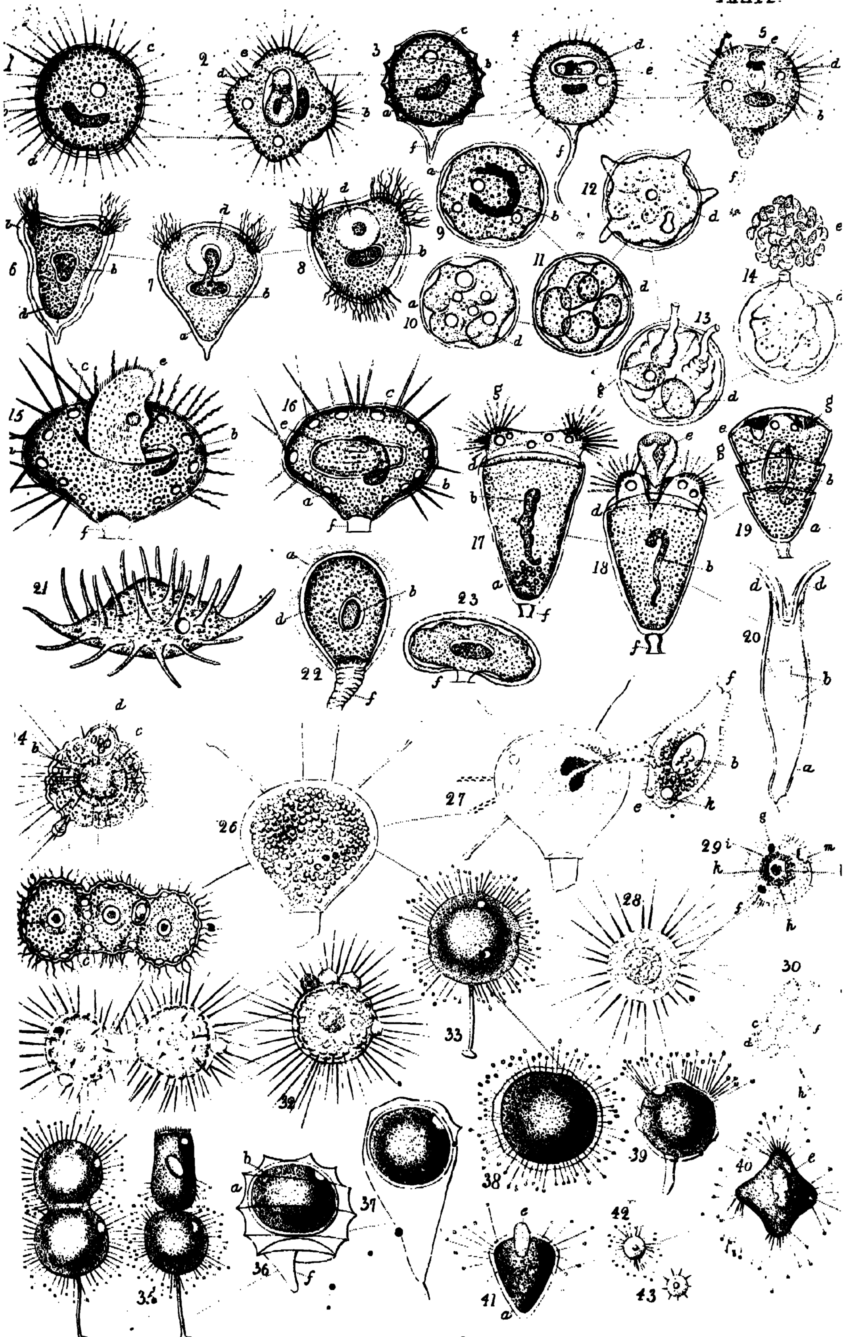

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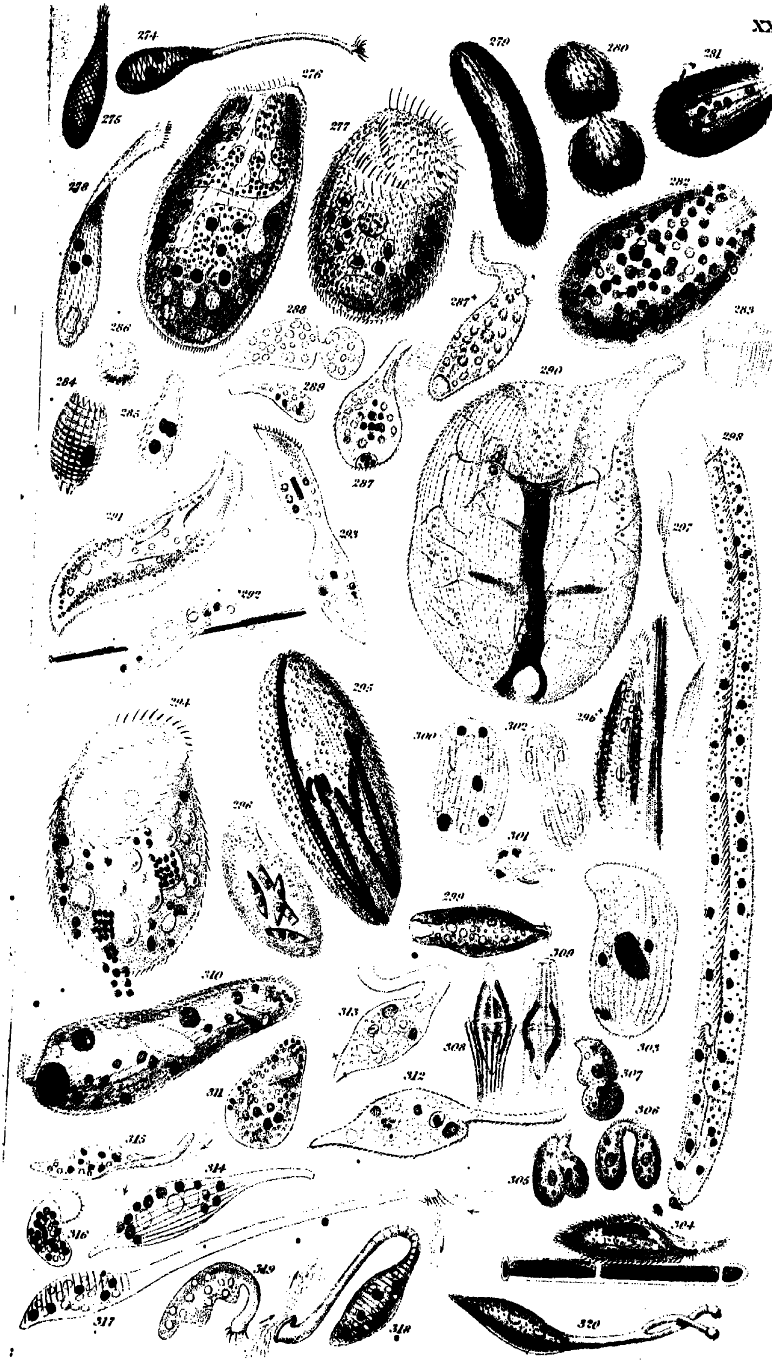
XXIV.



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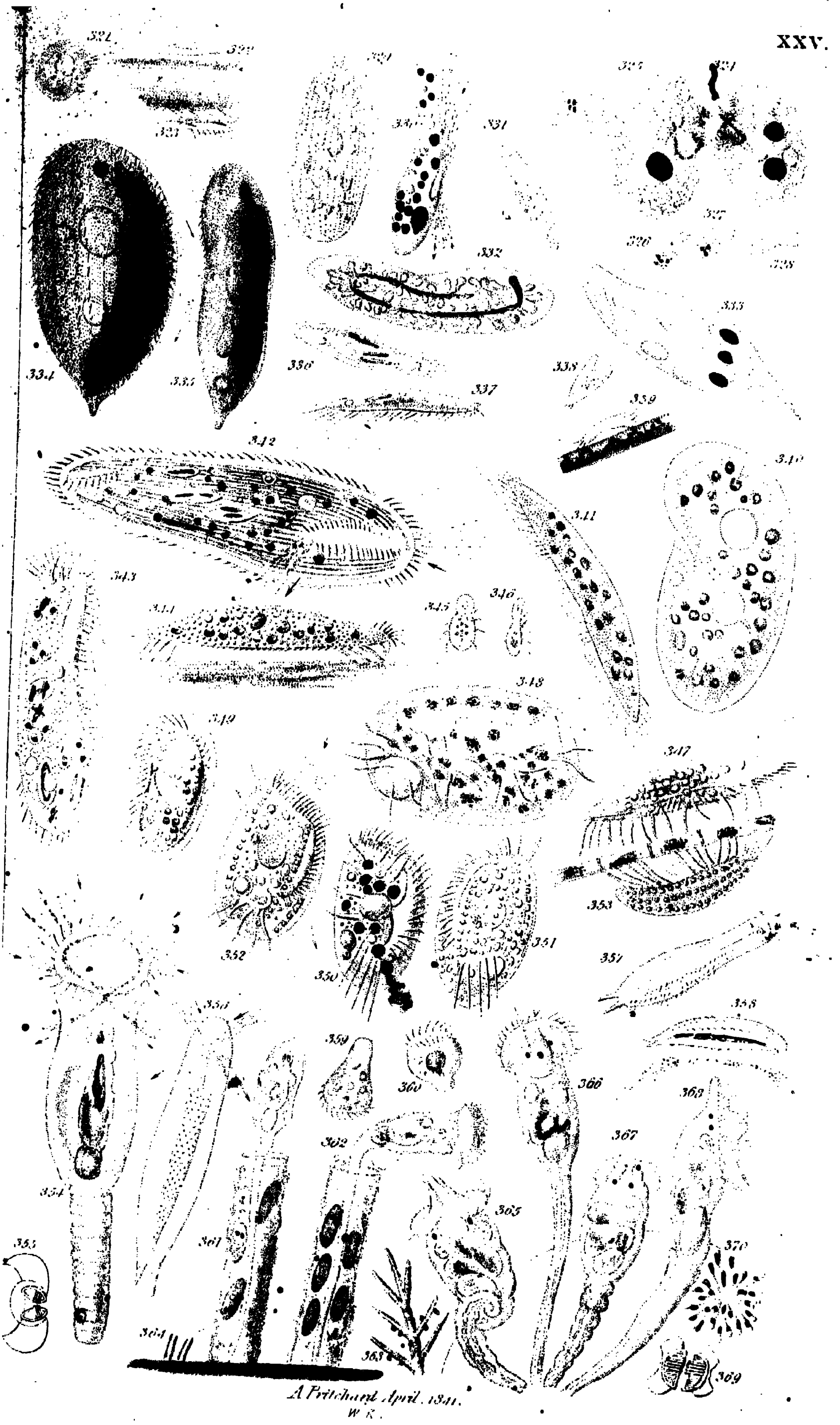

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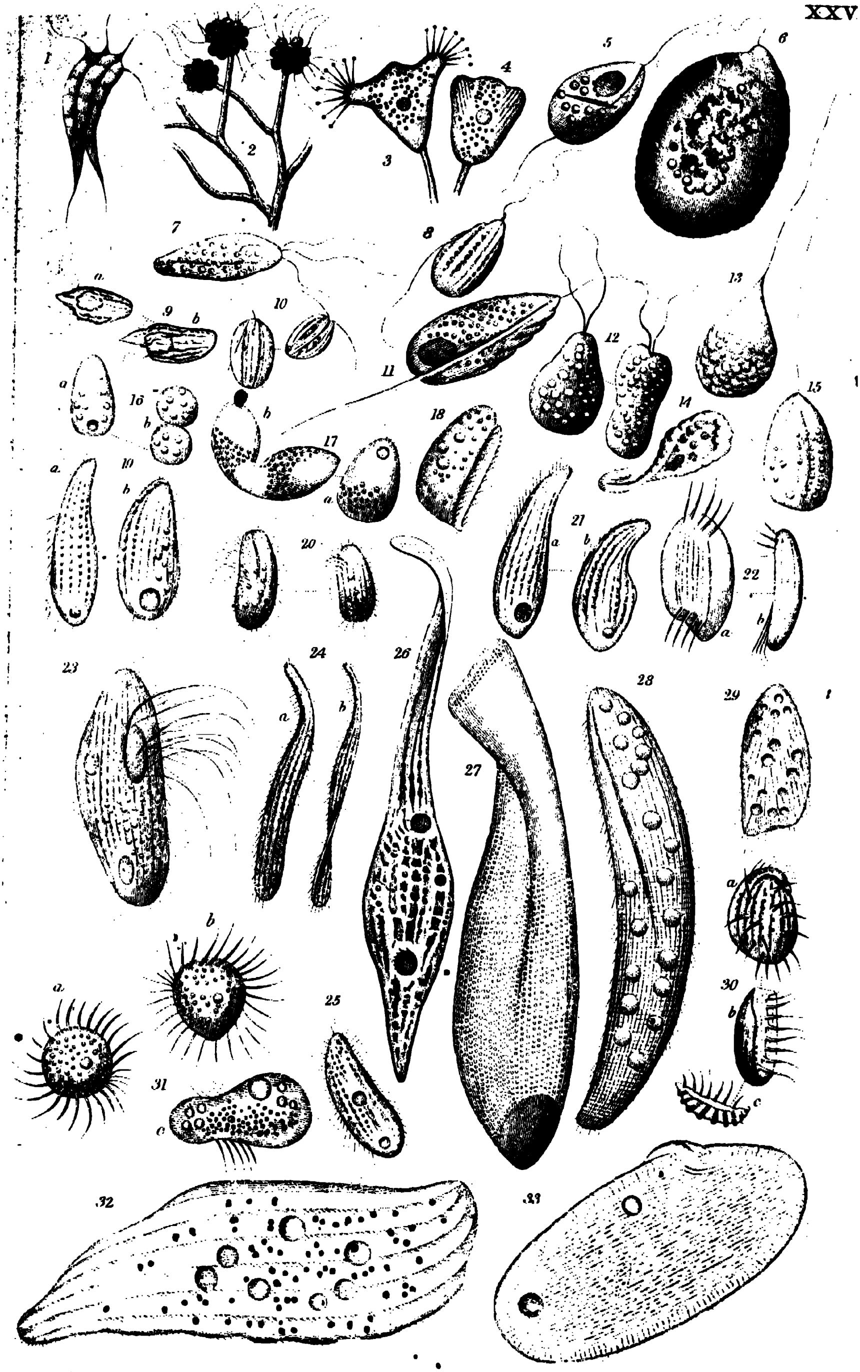
W K.

XXV



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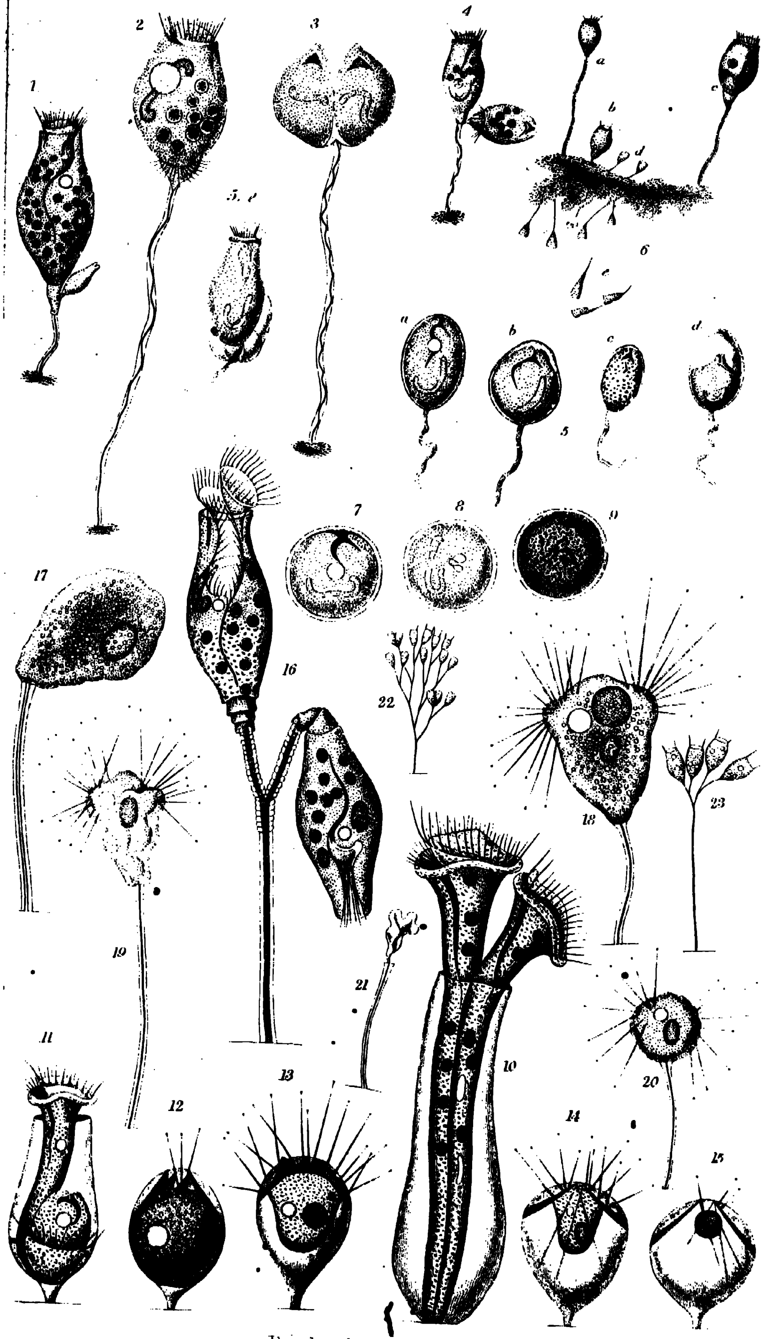

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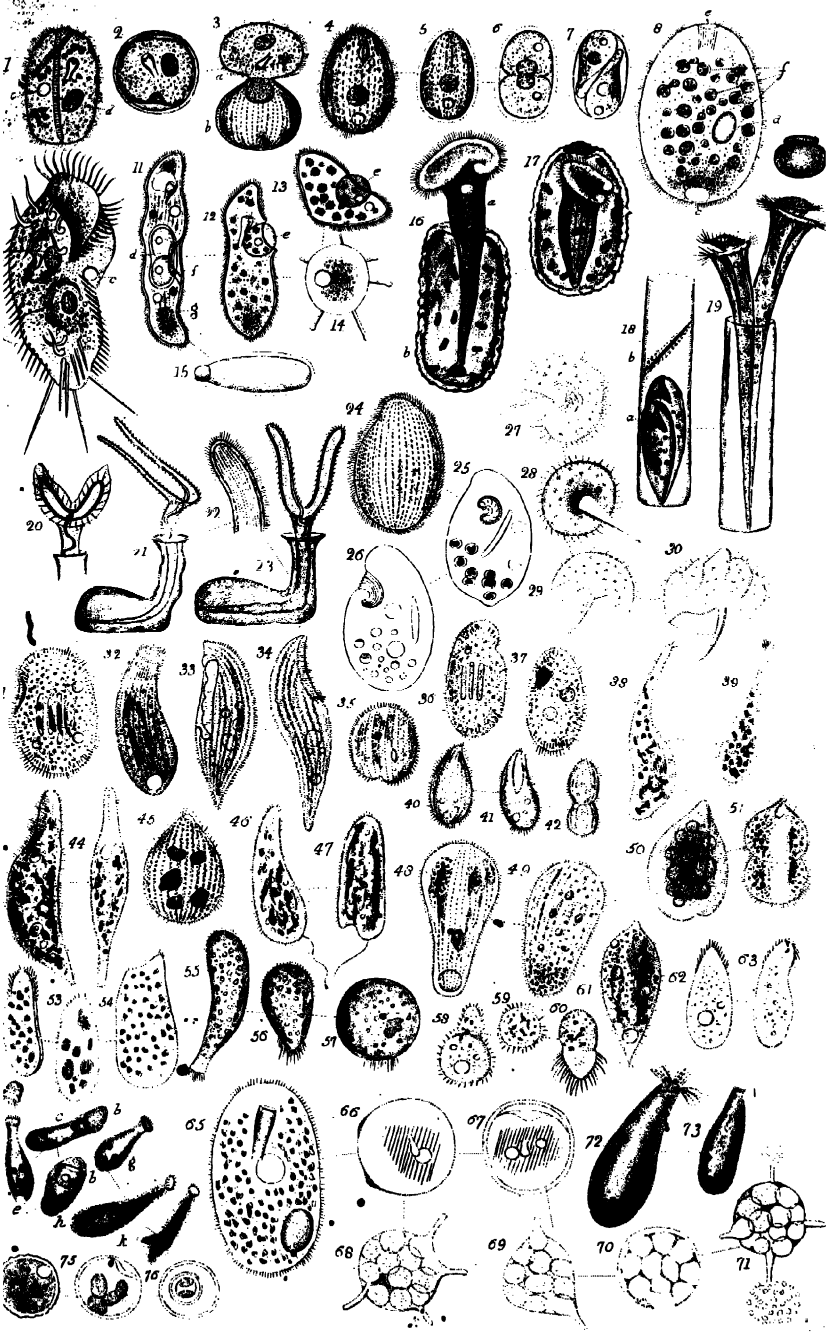

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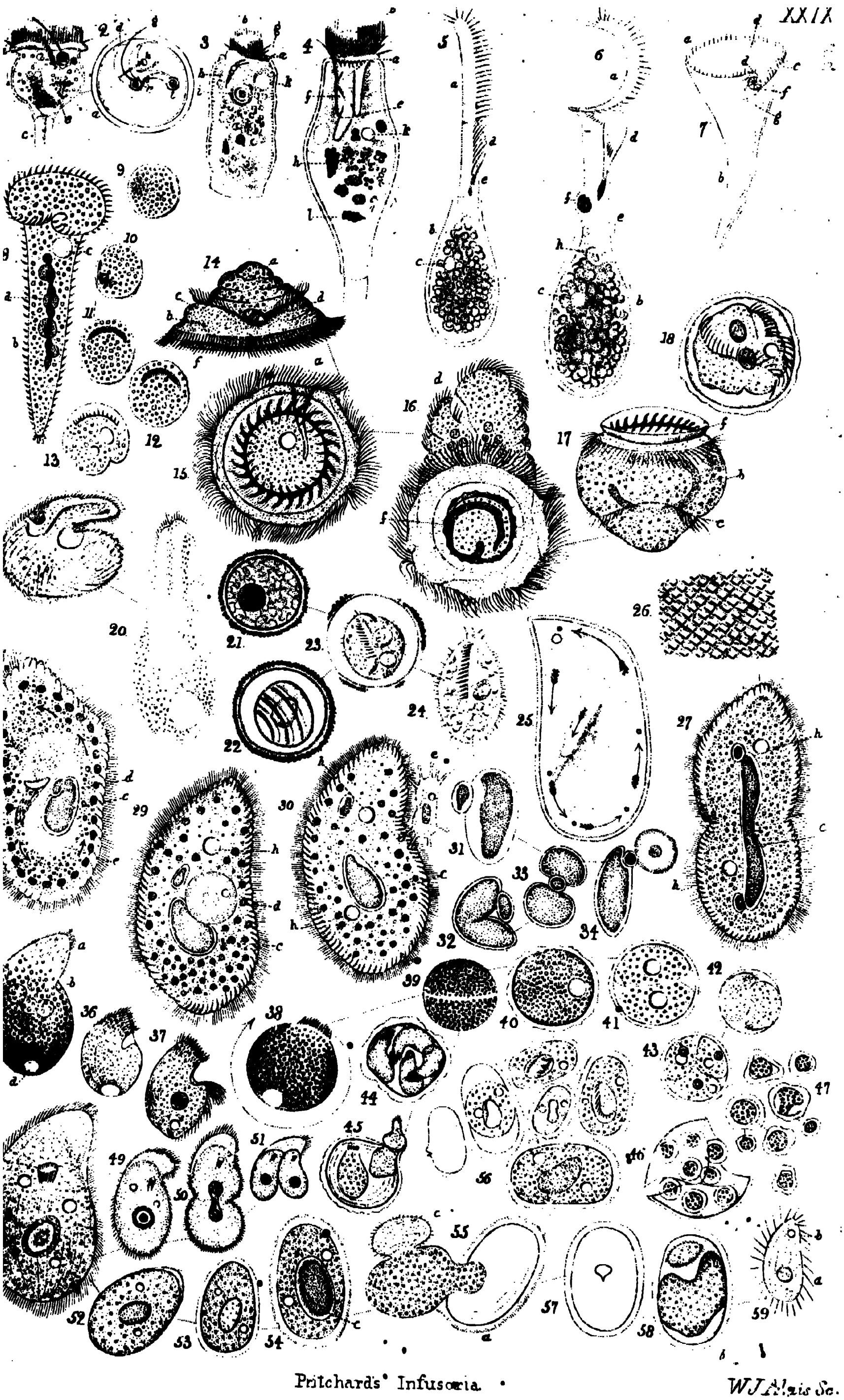

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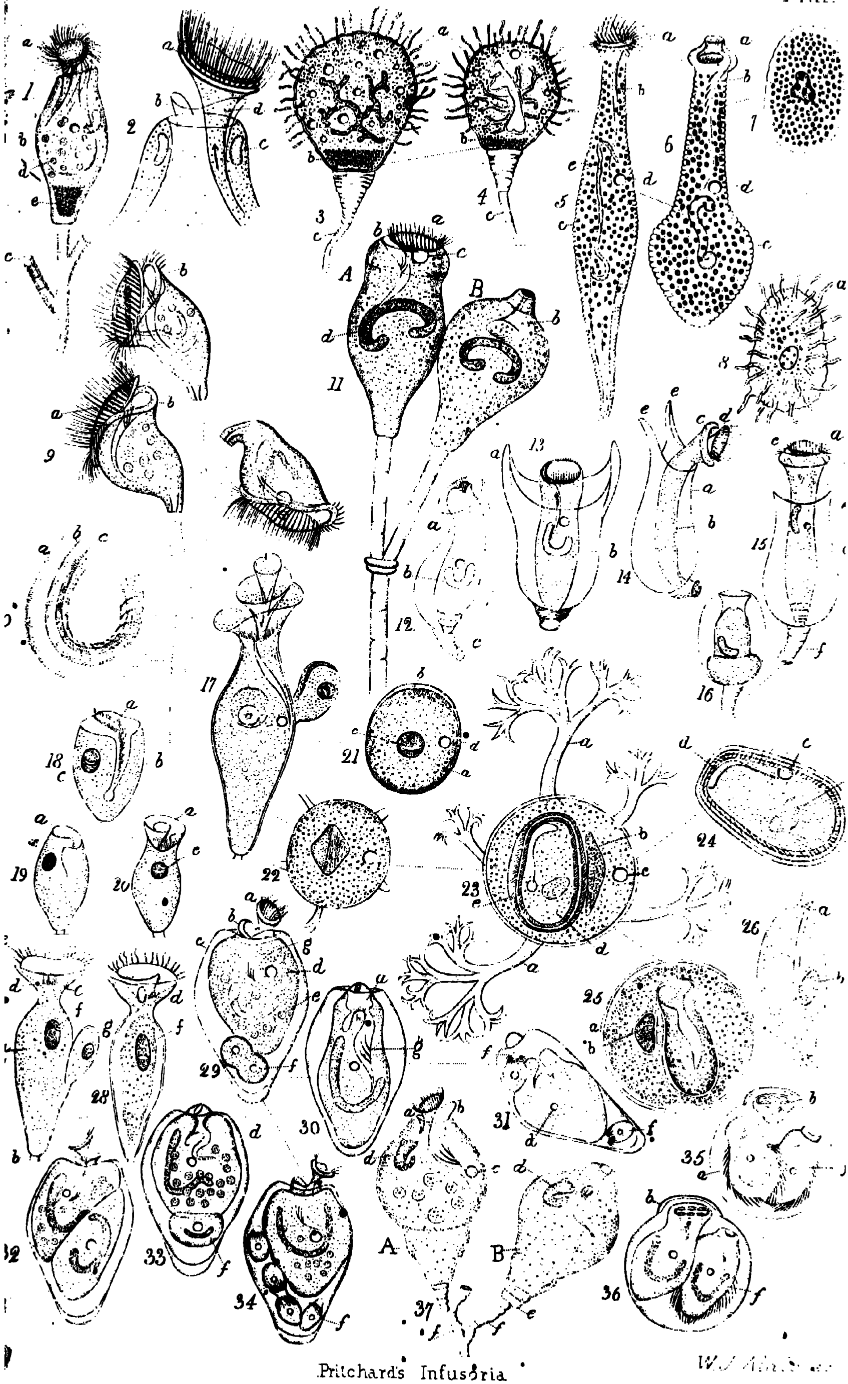

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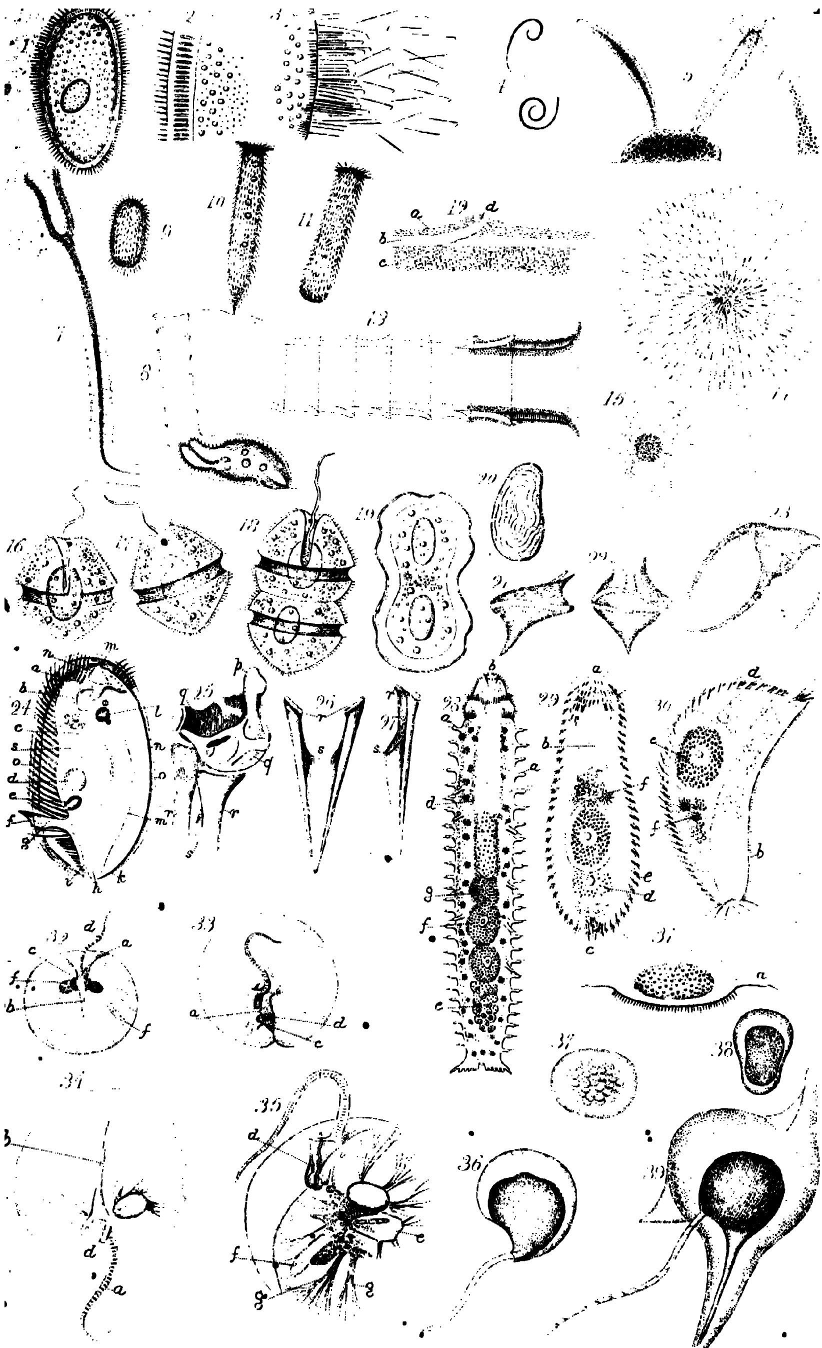

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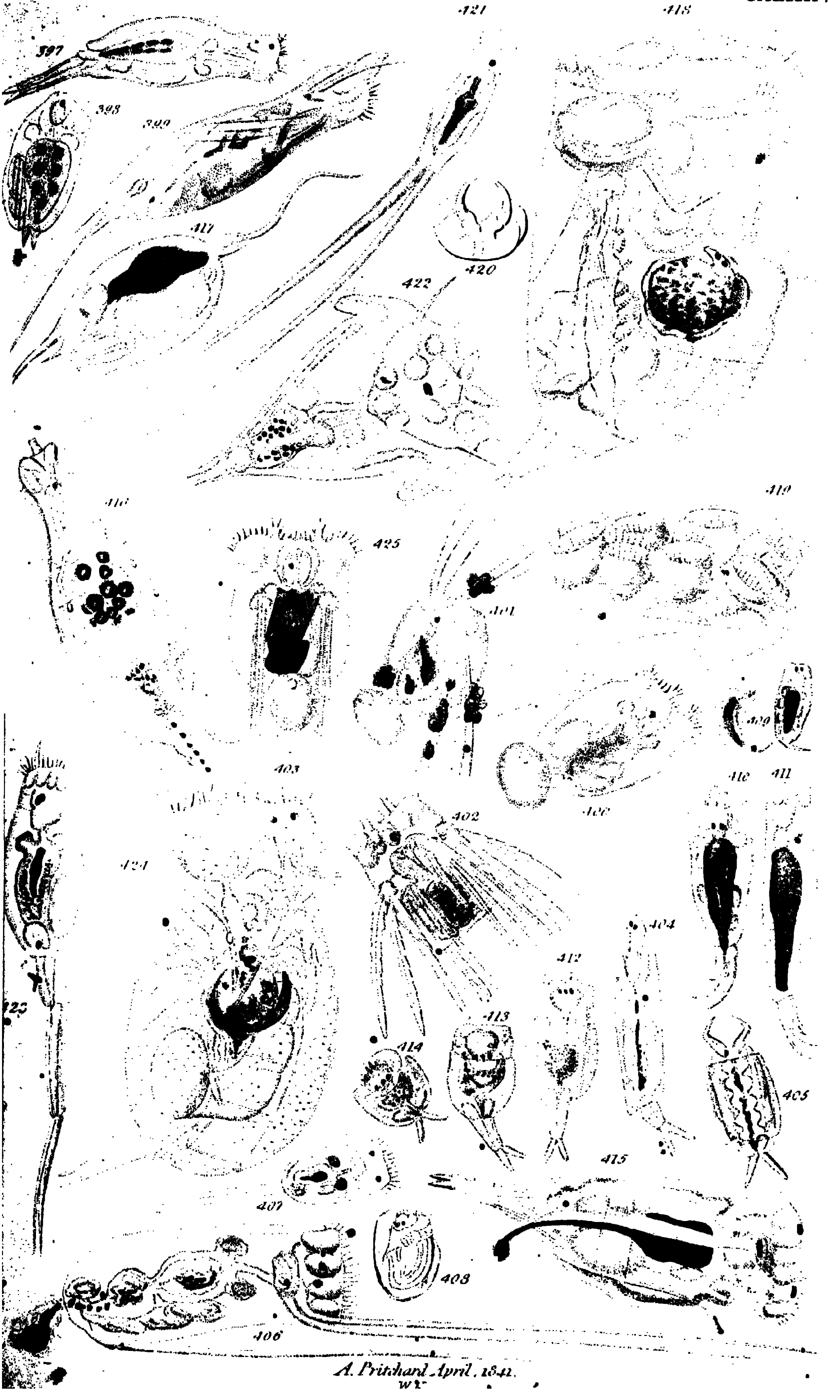
XXXIII.



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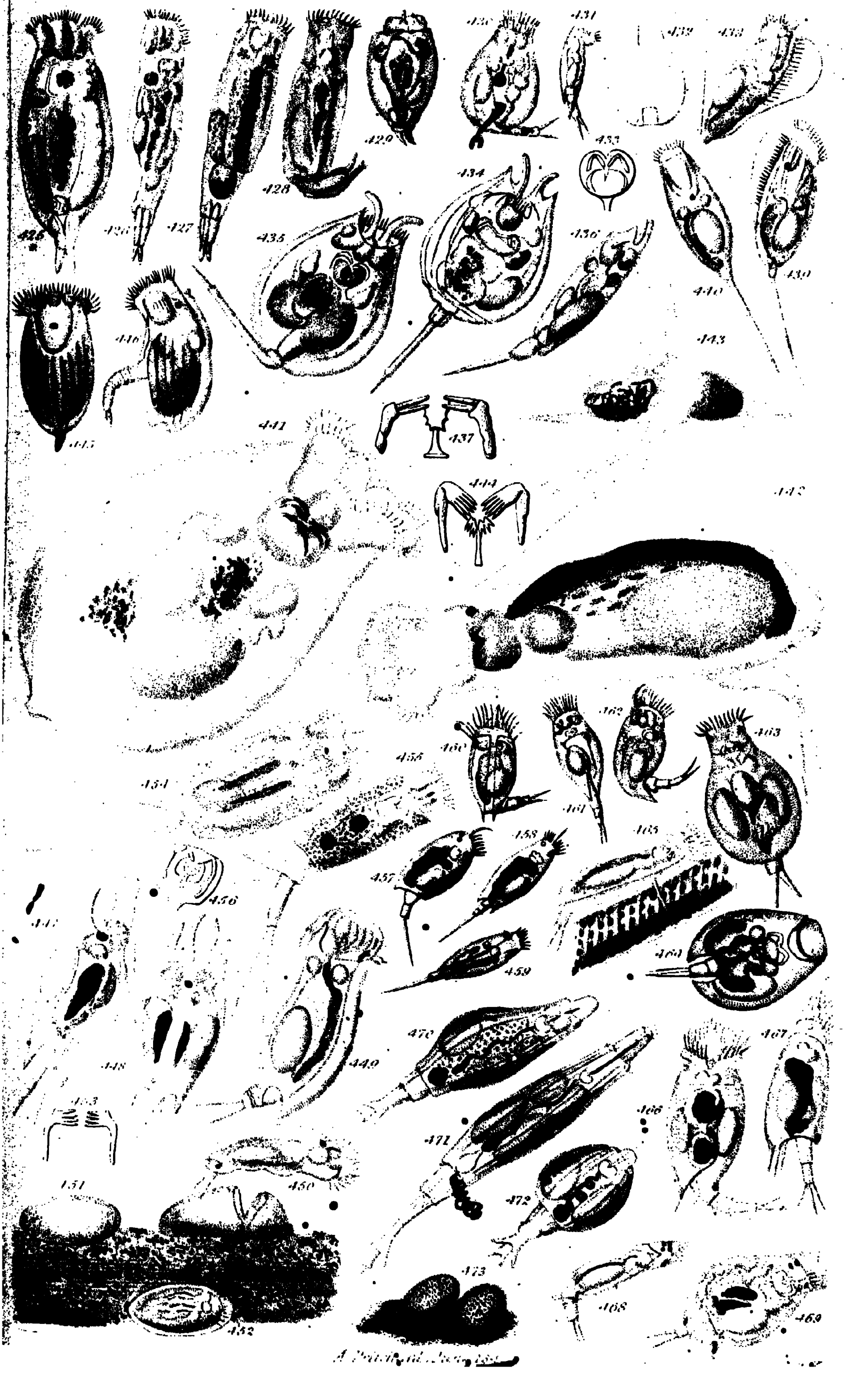

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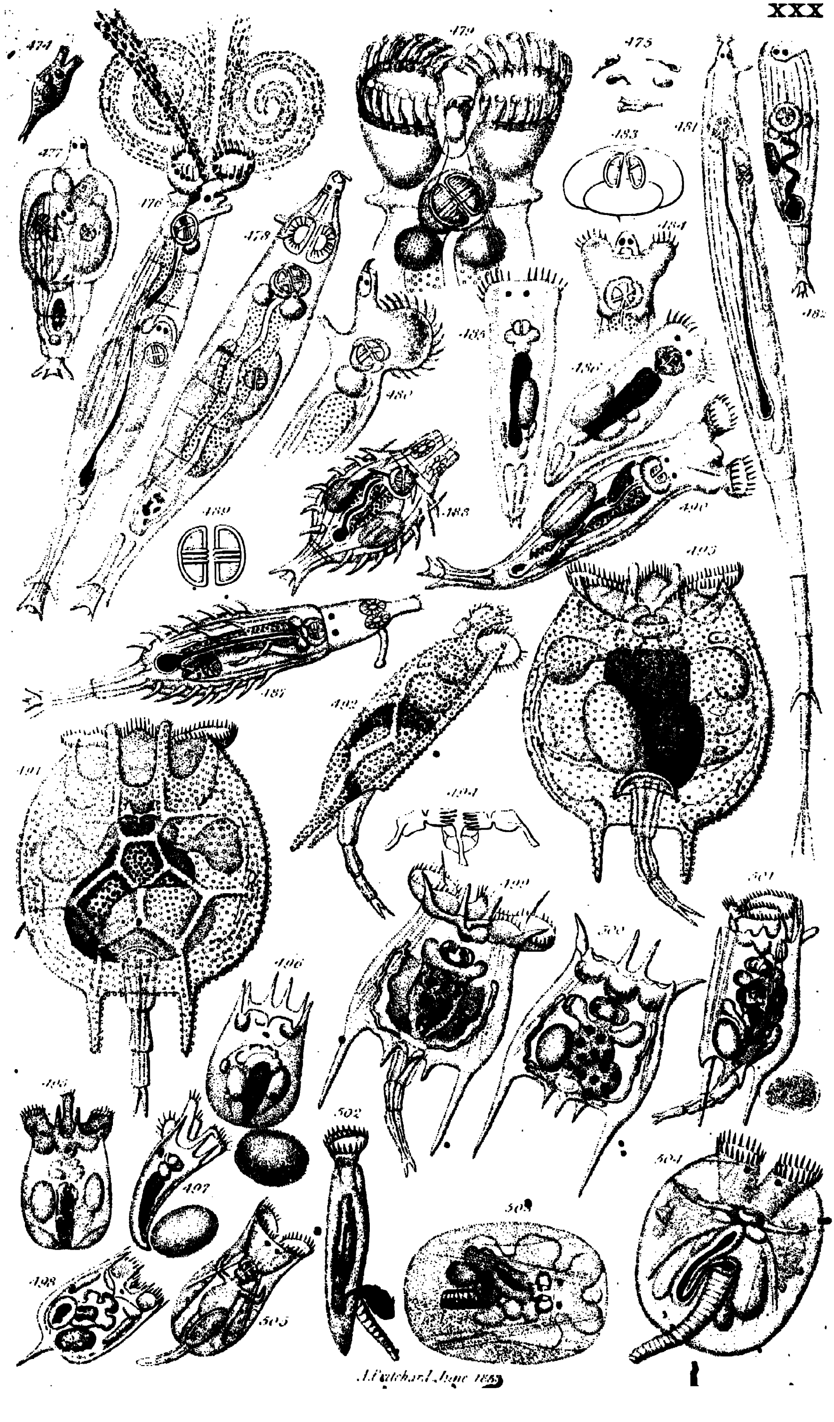

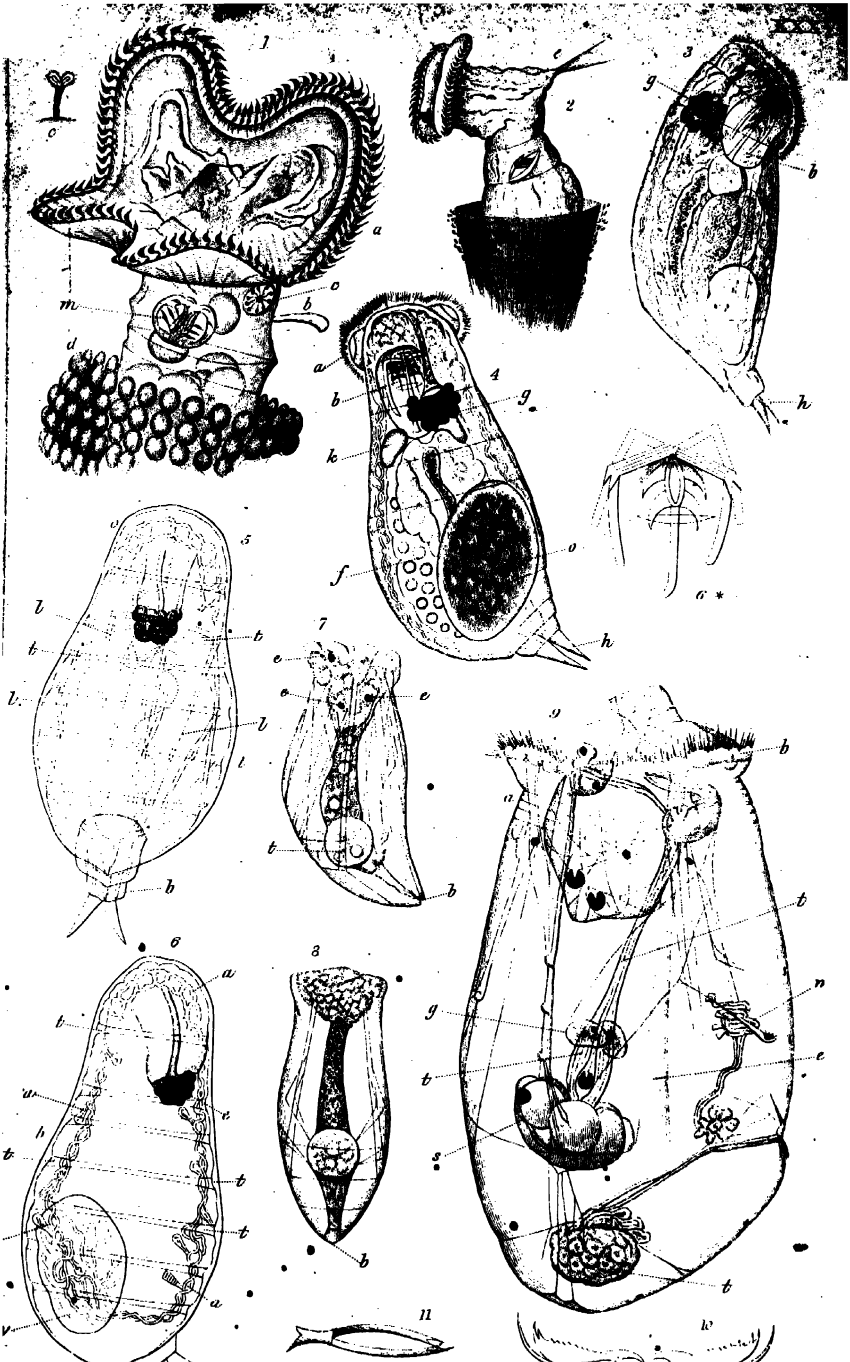

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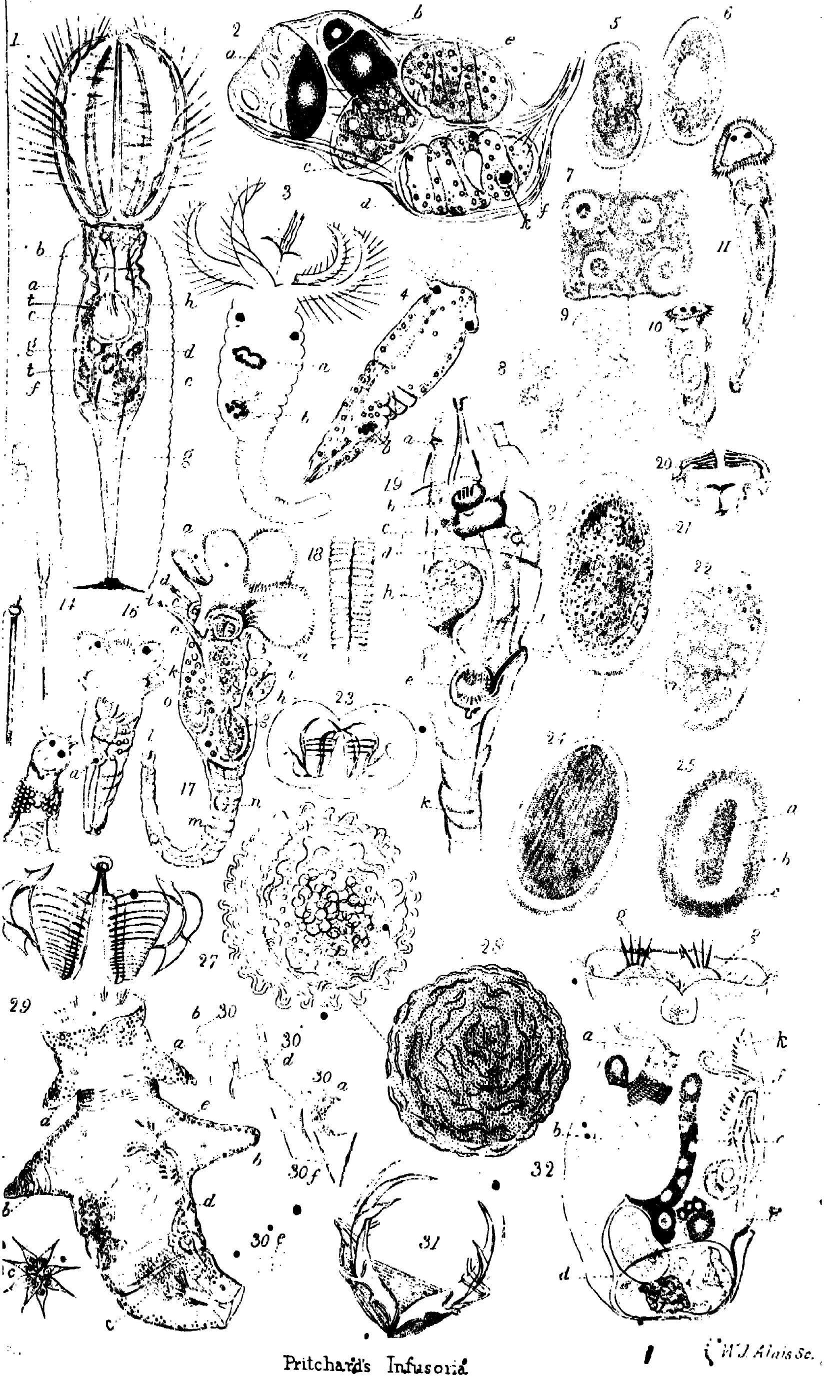
Pritchard's Infusoria

XXXVII



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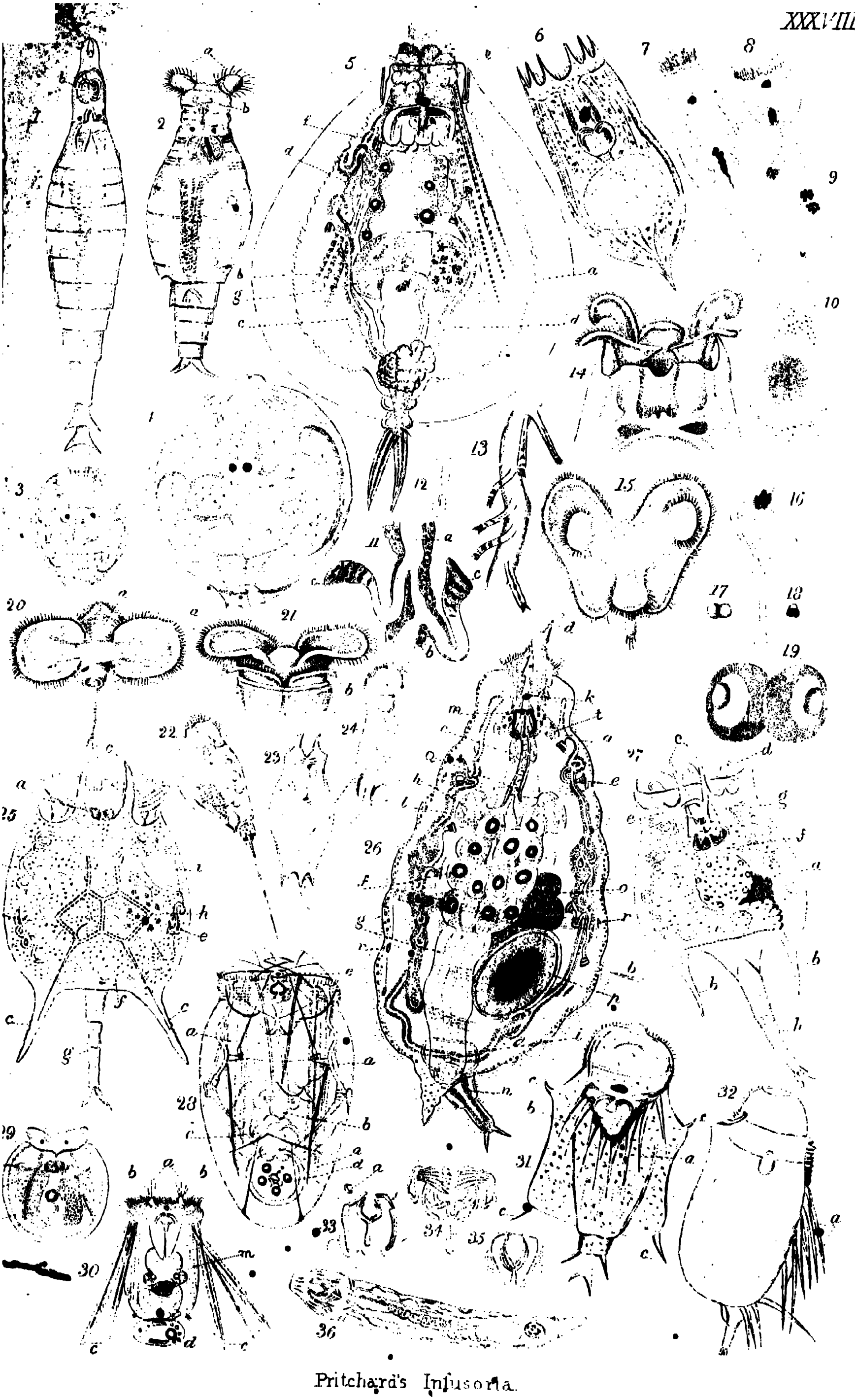
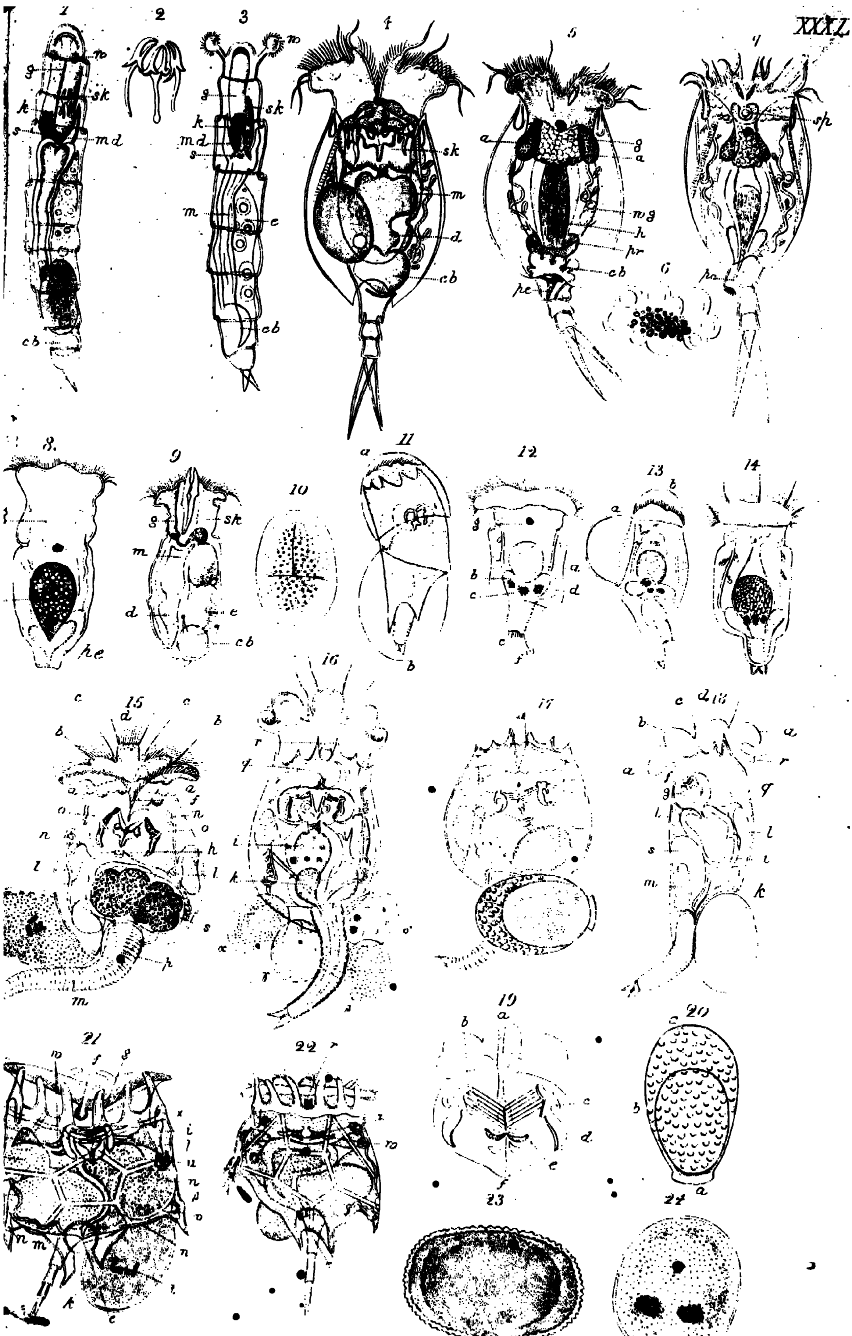


Pritchard's Infusoria.

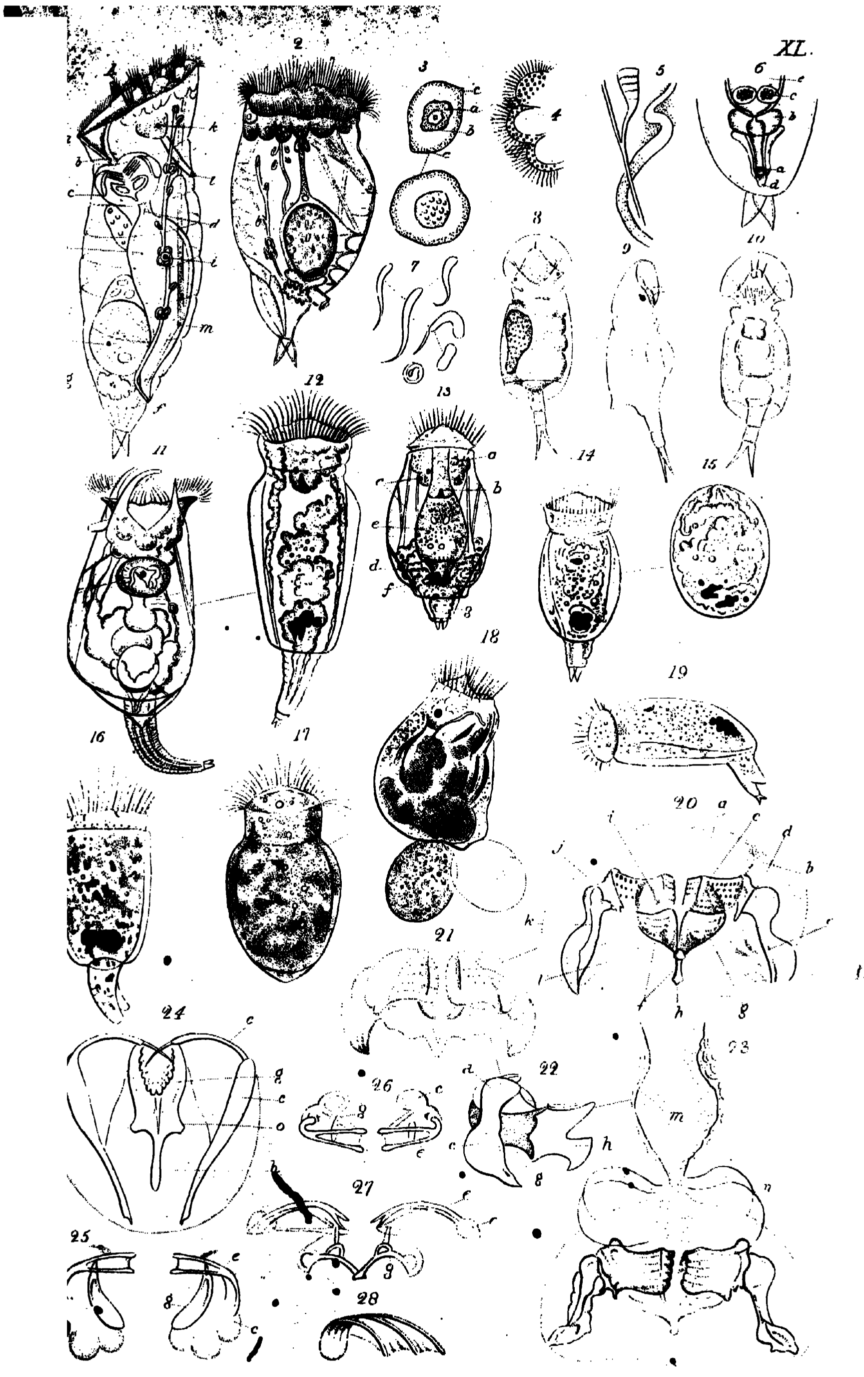
XXXI.



Pritchard's Infusoria.

[illegible] sc.

XL.



Pritchard's Infusoria.

W. J. Alais, sc.