TRANSACTIONS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

PROCEEDINGS

AND

TRANSACTIONS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

VOL. IV.

SESSION 1889—90.

LIVERPOOL:
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CONTENTS.

I. Proceedings.

II. Transactions.

ERRATA.

Page 34, line 6 from foot, for "and" read "as ovule is."

Page 62, line 6 from foot, for "*swammerdamii*" read "*vedlomensis*."

Page 72, line 7 from top, delete from "possibly" to end of sentence, and substitute "*D. bradyi* may be the same species as *D. spinosa*."

Page 178, line 15 from foot, for "dorsal" read "anterior."

PROCEEDINGS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

OFFICE-BEARERS AND COUNCIL

FOR SESSION IV., 1889—90.

President:

PROFESSOR W. A. HERDMAN, D.Sc., F.L.S., F.R.S.E.

Vice-Presidents:

J. DRYSDALE, M.D., F.R.M.S.

T. J. MOORE, CORR. M.Z.S.LONDON.

Hon. Treasurer:

ISAAC C. THOMPSON, F.L.S., F.R.M.S.

Hon. Librarian:

R. HANITSCH, PH.D.

Hon. Secretary:

F. CHAS. LARKIN, F.R.C.S., &c.

Council:

H. C. BEASLEY.

N. CAINE.

PROF. CATON, M.D., F.R.C.P.

R. J. HARVEY GIBSON, M.A., F.L.S.

T. HIGGIN, F.L.S.

ALFRED LEICESTER.

J. LOMAS, ASSOC. N.S.S.

G. H. MORTON, F.G.S.

W. NARRAMORE, F.L.S.

PROF. PHILLIPS, M.A., B.Sc.

SIR JAMES POOLE.

THOS. C. RYLEY.

REPORT of the COUNCIL.

Your Council has the pleasure of reporting that the fourth session (1889-90) has been in every way a successful one, and has been marked by a continued steady advance in the influence and usefulness of the Society.

There have, as usual, been eight ordinary evening meetings at University College (October to May), and one day field-meeting at Hilbre Island in July.

The attendance at the meetings has been good, and the interest taken by the members in the work of the Society seems to be constantly increasing. The number of Communications has been large, and they have extended over all departments of Biology.

The Library has been very greatly increased during the session and now contains eight hundred and twenty-eight volumes and pamphlets. Exchanges have been arranged with a number of additional societies at home and abroad, and others are in process of negociation or in contemplation. The bookcase containing the library is now more than filled, and additional shelving is very urgently required.

After careful consideration at two successive meetings of Council it was decided, on December 13th, 1889, that, beginning with the present session, the publications of the Society should be issued as "Proceedings and Transactions of the Liverpool Biological Society," and that there should be two distinct parts:—(1.) "Proceedings," consisting of the official lists, laws, and announcements of the Society, the reports of the Council, Treasurer, and Librarian, and of a summary of the proceedings at each meeting of the Society, arranged chronologically; and (2.) "Transactions," consisting of the original papers read before the Society and passed for publication, printed in full with their illustrations. This decision was reported to the Society by the President at the December meeting, and was approved of: the change will be found carried out in the present volume.

An important Bye-law has been added during this session to the effect that Student members of the Society may be admitted as ordinary members without re-election, upon payment of the ordinary members' subscription; and that they be exempt from the ordinary members' entrance fee.

His Highness Albert I., Prince of Monaco, who has for some years carried on important biological investigations in the Mediterranean and the North Atlantic in his yacht "Hirondelle," and has invented a number of ingenious new instruments for submarine exploration, has been added to the list of Honorary Members of the Society.

During the session 2 Ordinary members have resigned, and 6 have been elected; while 6 Student members have resigned and 13 have joined the Society. The number of members at present on the roll is:—

Honorary Members	6
Ordinary Members	65
Student Members............	40
Total..................	111

SUMMARY of PROCEEDINGS at the MEETINGS.

The first meeting of the fourth session was held at University College on October 11th, 1890, Professor W. A. Herdman, D.Sc., President, in the chair. There was a large attendance.

1. The Report of the Council on the Session 1888-89 (see "Proceedings," Vol. III., p. viii.) was read by the Secretary and approved.
2. The Treasurer's Balance-sheet for Session 1888-89 (see "Proceedings," Vol. III., p. 291) was submitted and approved.
3. The Report on the Library (see "Proceedings," Vol. III., p. 288) was read by the Librarian and approved.
4. His Highness Albert I., Prince of Monaco, was elected an Honorary Member of the Society.
5. The following were elected Office-bearers and Council for the new session:—Vice-Presidents, J. Drysdale, M.D., and T. J. Moore, C.M.Z. S.L.; Treasurer, I. C. Thompson, F.L.S.; Librarian, R. Hanitsch, Ph.D.; Secretary, F. C. Larkin, F.R.C.S.; Council, H. C. Beasley, N. Caine, Prof. Caton, M.D., R. J. H. Gibson, F.L.S., T. Higgin, F.L.S., Alf. Leicester, J. Lomas, G. H. Morton, F.G.S., W. Narramore, F.L.S., Prof. Phillips, M.A., Sir James Poole, and Thomas C. Ryley.
6. The President read his opening address upon "The Position and Work of a Biological Society, with Suggestions as to lines of Research in Marine Biology" (see "Transactions," this volume, p. 1).

    A vote of thanks to the President was proposed by Dr. Drysdale, seconded by Dr. C. H. Hurst, Owens College, and accorded.

The second meeting was held at University College on November 8th, Prof. Herdman, President, in the chair.

1. It was proposed (due notice having been given in accordance with the laws) and formally resolved that the Bye-law in regard to Student Members previously formed by the Council should be converted into a law (No. XIII. in the list of laws).
2. The President gave a short account of the recent discovery by Professor Giard of a "phosphorescence" amongst Amphipoda, caused by an infectious disease.
3. Mr. I. C. Thompson, F.L.S., exhibited and described a collection of Land Shells from the Hawaian Isles, sent by H.M. King Kalakao.
4. Professor L. C. Miall, Yorkshire College, Leeds, gave an account of his investigations into the Structure and Life-history of some Flies of the genus *Chironomus*. The eggs of *Chironomus*, one of the Diptera, are laid in stagnant water round an elaborately twisted gelatinous cord. The larvæ burrow in the mud, and stick the particles together with their saliva. They are of a bright red colour (due to hæmoglobin), and of active habit. The amount of hæmoglobin in the three genera *Chironomus* (much), *Tanypus* (less), and *Culex* (none) is in inverse proportion to the extent of the tracheal respiratory system, which is rudimentary in *Chironomus* and well developed in *Culex*. The larva of *Chironomus* is from its transparency especially suitable for the study of the histology of the internal organs in a living condition. A number of the details of struc-

ture of the larva, and of the development of the fly within the body of the larva were described and illustrated with original drawings, which will be published when the work is more complete.

The third meeting was held at University College on December 13th, Prof. Herdman, President, in the chair.

1. It was announced that the Council had decided that in future, and commencing with the present session, the publications of the Society should be divided into two parts:—(A.) "Proceedings" and (B.) "Transactions."
2. It was announced that the Council had framed a Bye-law for the purpose of facilitating the transformation of a Student member into an Ordinary member. (See Laws, p. xxii.).
3. Professor Herdman intimated that the "Phosphorescence" in Amphipoda, caused by a micro-organism, which he had described at the previous meeting, had since been found at Jersey by Mr. J. Sinel.
4. Note on some habits of Crustacea, by Alfred O. Walker, F.L.S. (See Transactions, p. 84.).
5. Additional Notes on the Terminology of Reproductive Organs of Plants, by R. J. Harvey Gibson, M.A. (See Transactions, p. 24.).
6. Report on the Land Mollusca of Puffin Island and the neighbourhood, by Alf. Leicester. (See Transactions, p. 87.).
7. The third Annual Report on the Puffin Island Biological Station, and on the L.M.B.C. Dredging Expeditions during 1889, was laid before the meeting by Prof. Herdman. (See Transactions, p. 36).
8. Mr. W. J. Halls exhibited, with remarks, some Marine

Crustacea (*Palæmon varians*), caught in fresh or brackish water near the sea.

The fourth meeting was held at University College on January 10th, 1890, Prof. Herdman, President, in the chair.

1. The Hon. Librarian announced and exhibited additions to the Society's Library received during the last month, amounting to 180 volumes.
2. Prof. Herdman gave a short account of the investigations recently made at the Scottish Marine Station, Granton, into the method of formation of carbonate of lime shells or exo-skeletons by various marine animals.
3. Mr. J. Lomas exhibited and described a Quern, presented to the Zoological Museum by Mr. D. Davies.
4. Professor Caton, M.D., exhibited a specimen of the New Zealand "Kea" (*Nestor notabilis*), and described its remarkable and recently-acquired habit of attacking sheep in the region of the kidney. The specimen has been deposited in the Zoological Museum of the College.
5. Dr. C. Herbert Hurst, Lecturer on Zoology, Owens College, Manchester, gave an account of his recent investigations on the Pupal State of *Culex*. (See Transactions, p. 170.).

The fifth meeting was held at University College, on February 14th, Prof. Herdman, President, in the chair. There was a large attendance.

1. Prof. Herdman gave notice that the Biological Station on Puffin Island would be re-opened in April—or even earlier if any members wished to make use of it during March.

2. Prof. Herdman intimated that he had started the collection of a number of statistics in regard to the Shrimp Fishery, and the habits of Shrimps, in the neighbourhood of Liverpool.
3. Note on the Stinging Hairs of the Nettle (*Urtica dioica*), by R. J. Harvey Gibson, M.A., and Miss Amy Warham, B.Sc. (See Transactions, p. 91).
4. Note on a Collection of Mummy Cats, Dogs, Ichneumons, &c., from Egypt. By Prof. Herdman, D.Sc. (See Transactions, p. 95).

   This paper gave rise to an interesting discussion, in which Principal Rendall, Professor Strong, Dr. Newton, Mr. Moore, and others took part. The specimens are now deposited in the Zoological Museum of University College, Liverpool.
5. Mr. I. C. Thompson, F.L.S., exhibited, with remarks, a small collection of Foraminifera from Puffin Island.
6. Professor Herdman exhibited, with remarks, a small collection of Fossil Teeth, &c., dredged from the bottom of the Bull River in Port Royal, S. Carolina, U.S.A., and presented to the Zoological Museum of University College, by Capt. Fred. Wyse. The following genera are represented:—*Elephas*, *Mastodon*, *Equus*, *Carcharodon*, *Lamna*, *Hemipristis*, *Galeocerda*, *Oxyrrhina*, and *Myliobatis*, along with whales' ear bones and some Lamellibranchs.
7. Dr. Hanitsch exhibited a selection of drawers from the type collection of Insects now being formed in the Zoological Museum of University College.

The sixth meeting was held at University College on March 14th, Professor Herdman, President, in the chair.

1. Prof. Herdman intimated that, in connection with the enquiry which had been started into the habits, &c.,

of Shrimps, he had already received a number of answers to his circulars from fishermen and others, and that he proposed to lay the tabulated results for the year before the Society during next session.

2. Prof. Herdman gave a short account of some experiments which he was making along with Mr. T. J. Moore, at the Aquarium of the Free Public Museum, upon the results of offering Nudibranchs to various Fishes. (See Transactions, p. 150).

3. Mr. J. Lomas exhibited, with remarks, some specimens of Flexible Sandstone; and also some Gnawed Hazel Nuts from the clay of the Manchester Ship Canal cutting at Barton.

4. Mr. Harvey Gibson exhibited some of the stages of karyokinesis as shown in pollen grains.

5. Reproduction among the lower forms of Vegetable Life. By A. W. Bennett, M.A., B.Sc., &c. (See Transactions, p. 97).

The seventh meeting was held at University College on April 11th, Dr. Drysdale, Vice-President, in the chair.

1. Mr. H. C. Beasley read a note on the number of moths caught during the various phases of the moon by Mr. Dukinfield Jones at San Paolo, in Brazil.

2. Mr. I. C. Thompson gave an account of his recent visit to the Biological Station on Puffin Island, stating the improvements which had been made in the sleeping accommodation, and the work he and the others had been engaged on.

3. Mr. T. J. Moore exhibited some living specimens of the Sea-mouse (*Aphrodita aculeata*).

4. Note on *Monstrilla* and the Cymbasomatidæ, by I. C. Thompson, F.L.S. (See Transactions, p. 115).

5. Mr. R. J. Harvey Gibson read the first part of a paper

by himself and Miss E. M. Smith, on the minute structure of the nectaries of Orchids. The genera discussed were *Angræcum*, *Macroplectum*, and *Coryanthes*.

6. Dr. R. Hanitsch exhibited, with remarks, a number of sections of embryo Frogs (from first to tenth day) and Rabbits (first, second, and third weeks).
7. Mr. J. Lomas exhibited and described a Polyzoon (*Lepralia edax*), new to the L.M.B.C. district, found at the Isle of Man.

The eighth meeting was held at University College on May 9th, Professor Herdman, President, in the chair.

1. A vote of thanks to Mr. A. W. Bennett, for his address at the March meeting, was proposed by Professor Herdman, seconded by Mr. Harvey Gibson and accorded unanimously.
2. Third Report on the Nudibranchiata of the L.M.B.C. District. By Prof. Herdman and Mr. J. A. Clubb. (See Transactions, p. 131).
3. Third Report on the Porifera of the L.M.B.C. District. By Dr. R. Hanitsch. (See Transactions, p. 192).
4. Mr. Chalmers exhibited, with remarks, a small collection of Obsidian Arrowheads, &c., which he had found in California.
5. Mr. J. Hornell exhibited, with remarks, some microscopic specimens of *Caprella*, *Asterias*, *Pycnogonum*, *Lucernaria*, and other invertebrates, which he had prepared.
6. On Cross- and Self-fertilization among Plants. By R. J. Harvey Gibson, M.A., F.L.S. (See Transactions, p. 125).

7. Mr. T. J. Moore exhibited, with remarks, a living specimen of the Angler-fish (*Lophius piscatorius*).
8. Report on the Higher Crustacea of the L.M.B.C. District, collected in 1889. By A. O. Walker, F.L.S. (See Transactions, p 239.).

The ninth and last meeting of the session took the form of a Field Meeting on July 5th, 1890, when the proceedings were as follows:—

1. A dredging expedition in the estuary of the Dee, in the steam-tug "Albert," of Mostyn.
2. Shore-collecting at low-tide on Hilbre Island.
3. After tea at the Dee Hotel, West Kirby, with Professor Herdman, President, in the chair, and about thirty members present, it was formally announced from the chair that Mr. T. J. Moore, Corr. Memb. Zool. Soc. London, Curator of the Liverpool Free Public Museum, had been chosen by the Council to be President for the next session.

   It was then proposed by Professor Herdman, seconded by Dr. Drysdale and carried unanimously, that the Society approve the decision of Council and elect Mr. Moore as President.

   A vote of thanks to Professor Herdman, the retiring President, was proposed by Mr. R. McMillan, seconded by Dr. Hurst, and carried unanimously.

LAWS of the LIVERPOOL BIOLOGICAL SOCIETY.

I.—The name of the Society shall be the "Liverpool Biological Society," and its object the advancement of Biological Science.

II.—The Ordinary Meetings of the Society shall be held at University College, at Seven o'clock, during the six Winter months, on the second Friday evening in every month, or at such other place or time as the Council may appoint.

III.—The business of the Society shall be conducted by a President, two Vice-Presidents, a Treasurer, a Secretary, a Librarian, and twelve other Members, who shall form a Council; four to constitute a quorum.

IV.—The President, Vice-Presidents, Treasurer, Secretary, Librarian, and Council shall be elected annually, by ballot, in the manner hereinafter mentioned.

V.—The President shall be elected by the Council (subject to the approval of the Society) at the last Meeting of the Session, and take office at the ensuing Annual Meeting.

VI.—The mode of election of the Vice-Presidents, Treasurer, Secretary, Librarian, and Council shall be in form and manner following:—It shall be the duty of the retiring Council at their final meeting to suggest the names of Members to fill the offices of Vice-Presidents, Treasurer, Secretary, Librarian, and of four Members who were not on the last Council to be on the Council for the ensuing session, and formally to submit to the Society, for election at the Annual Meeting, the names so suggested. The Secretary shall make out and send to each Member of the Society, with the circular convening the Annual Meeting, a printed list of the retiring Council, stating the date of the election of each Member, and the number of his attendances at the Council Meetings during the past session; and another containing the names of the Members suggested for election, by which lists, and no others, the votes shall be taken. It shall, however, be open to any Member to substitute any other names in place of those upon the lists, sufficient space being left for that purpose. Should any list when delivered to the President contain other than the proper number of names, that list and the votes thereby given shall be absolutely void. Every list must be handed in personally by the Member at the time of voting. Vacancies occurring otherwise than by regular annual retirement shall be filled by the Council.

VII.—Every Candidate for Membership shall be proposed by three or more Members, one of the proposers from personal knowledge. The nomination shall be read from the Chair at any Ordinary Meeting, and the Candidate therein recommended shall be balloted for at the succeeding Ordinary Meeting. Ten black balls shall exclude.

VIII.—When a person has been elected a Member, the Secretary shall inform him thereof, by letter, and shall at the same time forward him a copy of the Laws of the Society.

IX.—Every person so elected shall within one calendar month after the date of such election pay an Entrance Fee of Half a Guinea and an Annual Subscription of One

Guinea (except in the case of Student Members); but the Council shall have the power in exceptional cases, of extending the period for such payment. No Entrance Fee shall be paid on re-election by any Member who has paid such fee.

X.—The Subscription (except in the case of Student Members) shall be One Guinea per annum, payable in advance, on the day of the Annual Meeting in October.

XI.—Members may compound for their Annual Subscriptions by a single payment of Ten Guineas.

XII.—There shall also be a class of Student Members, paying an Entrance Fee of Two Shillings and Sixpence, and a Subscription of Five Shillings per annum.

XIII.—All nominations of Student Members shall be passed by the Council previous to nomination at an Ordinary Meeting. When elected, Student Members shall be entitled to all the privileges of Ordinary Members, except that they shall not receive the publications of the Society, nor vote at the Meetings, nor serve on the Council.

XIV.—Resignation of Membership shall be signified *in writing* to the Secretary, but the Member so resigning shall be liable for the payment of his Annual Subscription, and all arrears up to the date of his resignation.

XV.—The Annual Meeting shall be held on the second Friday in October, or such other convenient day in the month as the Council may appoint, when a Report of the Council on the affairs of the Society, and a Balance Sheet, duly signed by Auditors previously appointed by the Council, shall be read.

XVI.—Any person (not resident within ten miles of Liverpool) eminent in Biological Science, or who may have rendered valuable services to the Society, shall be eligible as an Honorary Member; but the number of such Members shall not exceed fifteen at any one time.

XVII.—Captains of vessels and others contributing objects of interest shall be admissible as Associates for a period of three years, subject to re-election at the end of that time.

XVIII.—Such Honorary Members and Associates shall be nominated by the Council, elected by a majority at an Ordinary Meeting, and have the privilege of attending and taking part in the Meetings of the Society, but not voting.

XIX.—Should there appear cause in the opinion of the Council for the expulsion from the Society of any Member, a Special General Meeting of the Society shall be called by the Council for that purpose; and if two-thirds of those voting agree that such Member be expelled, the Chairman shall declare this decision, and the name of such Member shall be erased from the books.

XX.—Every Member shall have the privilege of introducing one visitor at each Ordinary Meeting. The same person shall not be admissible more than twice during the same session.

XXI.—Notices of all Ordinary or Special Meetings shall be issued to each Member by the Secretary, at least three days before such Meeting.

XXII.—The President, Council, or any ten Members can convene a Special General Meeting, to be called within fourteen days, by giving notice in writing to the Secretary, and stating the object of the desired Meeting. The Circular convening the Meeting must state the purpose thereof.

XXIII.—Votes in all elections shall be taken by ballot, and in other cases by show of hands, unless a ballot be first demanded.

XXIV.—No alteration shall be made in these Laws, except at an Annual Meeting, or a Special Meeting called for that purpose; and notice in writing of any proposed alteration shall be given to the Council, and read at the Ordinary Meeting, at least a month previous to the meeting at which such alteration is to be considered, and the proposed alteration shall also be printed in the Circular convening such meeting; but the Council shall have the power of enacting such Bye-laws as may be deemed necessary, which Bye-laws shall have the full power of Laws until the ensuing Annual Meeting, or a Special Meeting convened for their consideration.

BYE-LAW.

Student Members of the Society may be admitted as Ordinary Members without re-election upon payment of the Ordinary Member's subscription; and they shall be exempt from the Ordinary Member's entrance fee.

LIST of MEMBERS of the LIVERPOOL BIOLOGICAL SOCIETY.

SESSION 1889-90.

A. Ordinary Members.

(Life Members are marked with an asterisk.)

ELECTED.

1888 Atkin, Hope T., Egerton House, Egerton Park, Rock Ferry

1886 Banks, Prof. W. Mitchell, M.D., F.R.C.S., 28, Rodney-street

1886 Barron, Prof. Alexander, M.B., M.R.C.S., 31, Rodney-street

1888 Beasley, Henry C., Prince Alfred-road, Wavertree

1890 Boulnois, H. Percy, M. Inst. C.E., Municipal Offices

1889 Brown, Prof. J. Campbell, University College

1889 Buchanan, J. R. M., M.D., 23, St. Alban's-road, Bootle

1887 Caine, Nathaniel, 10, Orange-court, Castle-street

1886 Caton, Prof. R., M.D., F.R.C.P., Lea Hall, Gateacre

1886 Chisholm, J. M., M.D., White House, Woolton

1886 Clubb, J. A., Zoological Laboratory, University College

1889 Davies, David, 55, Berkley-street

1886 Dillcock, T., 8, Church-street, Egremont

1886 Drysdale, John, M.D., Vice-President, 36a, Rodney Street.

1890 Dwerryhouse, Arthur R., Church-end Farm, Hale

1886 Edmonds, William, 69, Albany, Oldhall-street
1886 Ellis, J. W., M.B.Vic., F.E.S., 159, Howard-place, Shelton, Stoke-on-Trent
1890 Ewart, A. J., Botanical Laboratory, University College
1887 Gasking, Rev. S., B.A., F.G.S., The Parsonage, Skelmersdale, Ormskirk
1886 Glynn, Prof., M.D., F.R.C.P., 62, Rodney-street
1886 Gibson, R. J. Harvey, M.A., F.R.S.E., Botanical Laboratory, University College
1886 Gatehouse, C., Westwood, Noctorum, Birkenhead
1888 Gutridge, Henry, 102, Hartington-road
1886 Halhed, W. B., Sunnyside, Prince's Park
1886 Halls, W. J., 35, Lord-street
1887 Hanitsch, R., Ph.D., Librarian, Zoological Laboratory, University College
1887 Healey, George F., Oakfield, Gateacre
1886 Herdman, Prof. W.A., D.Sc., F.L.S., F.R.S.E., President, University College
1887 Hewitt, W., B.Sc., 16, Clarence-road, Birkenhead
1887 Higgin, T., F.L.S., Ethersall, Mossley Hill
1888 Hurst, C. H., Ph.D., Owens College, Manchester
1886 Jones, Charles W., Field House, Prince Alfred-road, Wavertree
1886 Larkin, F. C., F.R.C.S., Secretary, 29, Bedford-street North, or Physiological Laboratory, University College
1886 Leicester, Alfred, 24, Aughton-road, Birkdale
1886 Lomas, J., Assoc. N.S.S., 23, Avondale-street, Smithdown-road
1889 Macalister, E. L., Alexandra-terrace, Prince's-road
1888 Melly, W. R., 90, Chatham-street
1886 McMillan, Wm. S., F.L.S., Brook-road, Maghull
1886 McClelland, J., M.D., 7, Sefton-drive, Sefton Park

1886 Moore, Thomas J., C.M.Z.S., Vice-President, Free Museum
1886 Moore, G. F., 15, Kremlin-drive, Tuebrook
1886 Morton, G. H., F.G.S., 209, Edge-lane, E
1887 Narramore, W., F.L.S., 5, Geneva-road, Elm Park
1889 Newton, John, M.R.C.S., Rodney-street
1889 Ogle, John J., Museum, Bootle
1888 Phillips, Reg. W., B.A., University College, Bangor
1886 *Poole, Sir James, J.P., Abercromby-square
1886 Rathbone, Theodore, F.L.S., Backwood, Neston
1886 Read, William H., 6, Dingle-lane
1886 Roberts, I., F.R.S., F.G.S., Kennessee, Maghull
1887 Robertson, Helenus R., Glendaragh, Livingstone-drive
1887 Rowlands, W. Ellison, 28, Green-lane, Stoneycroft
1887 Ryley, Thomas C., 10, Waverley-road
1886 Smith, Andrew T., jun., 13, Bentley-road, Prince's Park
1889 Stewart, W. J., B.A., 26, Lord-street
1886 Tate, A. Norman, F.I.C., 9, Hackins-hey
1886 Thompson, Isaac C., F.L.S., F.R.M.S., Treasurer, Woodstock, Waverley-road
1889 Thurston, Edgar, Gov. Central Museum, Egmont, Madras, India
1888 Toll, J. M., 340, Walton Breck-road
1886 Vicars, John, 8, St. Albans-square, Bootle
1886 Walker, Alfred O., J.P., F.L.S., Colwyn Bay
1886 Walker, George, F.R.C.S., 45, Rodney-street
1889 Warriner, J. B., Central Buildings, North John-street
1889 White, Philip J., M.B., University College, Bangor
1889 Williams, Miss Leonora, 55, Rocky-lane

B. Student Members.

Armstrong, H., Stainland, Spital, Cheshire
Armstrong, Miss A., 26, Trinity-road, Bootle
Bell, R. G., 8, George's-hill
Browne, H. J. M., 39, Rodney-street
Buckley, Miss L., University College
Clapham, G. P. P., 13, Ducie-street
Coventry, P. H., 15, Albert-road, Birkdale
Delius, T., 41, Mulgrave-street
Dumergue, A. F., 79, Salisbury-road, Wavertree
Earnshaw, W. H., Leavy Greave, Rudgrave-place, Egremont
Edgecombe, W., Uplands, Blundellsands
Fowler, Miss C., High School, Belvidere-road
Gould, Joseph, Littledale-road, Egremont
Hannah, J. H. W., 4, Adderley-street, Edge-lane
Harding, Miss M., Kremlin-drive, West Derby
Hayward, W. D., 117, Grove-street
Henderson, W. S., 2, Holly-road, Fairfield
Hornell, James, 38, Church-street, Egremont
House, S. H., 44, Edge-lane
Hughes, W. Rathbone, 3, Prince's-gate, Prince's Park
Jones, C. R., St. John's Vicarage, Waterloo
McMillan, R., 20, Aubrey-street
Nixon, H. T., 40, Spellow-lane, Kirkdale
Nixon, J. P., 40, Spellow-lane, Kirkdale
O'Brien, Miss Mary, 47, Kingsley-road
Paden, R., Museum, William Brown-street
Palethorpe, Miss F., 85, Gladstone-road, Edgehill
Palmer, C. J. L., 24, Rock-park, Rock Ferry
Partridge, A. J., 25, Seacombe-villas, Seacombe
Quinn, J. Cardwell, Gateacre House, Gateacre
Radley, J. Trench, 4, Abercromby-square

Rathbone, Miss May, Backwood, Neston, Cheshire
Ross, S. G., 18, Lawrence-road, Wavertree
Sparrow, G. R., 7, Parkfield-road
Stahlknecht, B., 37, Prince's-avenue
Tarleton, Thomas, 1, Hyde-road, Waterloo
Veale, F. J. de C., 26, Linnet-lane
Warham, Miss, University College
Williams, Henry. Jun., 57, Balliol-road, Bootle
Willmer, Miss J. H., Fernleigh, Westbourne-road, Birkenhead

C. Honorary Members.

Claus, Prof. Carl, University, Vienna
Fritsch, Prof. Anton, Prague, Bohemia
Giard, Prof. Alfred, Sorbonne, Paris
H.H. King Kalakao, the Palace, Honolulu, Sandwich Islands
Marshall, Prof. A. Milnes, D.Sc., M.D., F.R.S., Owens College, Manchester
H.H. Albert I., Prince of Monaco

REPORT of the LIBRARIAN.

Our Society has arranged an exchange of publications with fourteen additional Societies since the last Report, making in all fifty two Societies. In July, 1889, the Library contained 364 volumes. It now numbers 828, an increase of 464 in the year. An additional bookcase is urgently required. The following list gives the titles of the exchanges received during this session :—

1. Archives Néerlandaises des Sciences exactes et naturelles. Tome xxiii., livr. 3—5. T. xxiv., livr. 1—3.
2. The Australian Museum, Sydney. Lord Howe Island. Catalogues: Hydroid Zoophytes, Fishes, Birds. Skeleton of a new Sperm Whale. "Records." Vol. i., Nos. 1 and 2.
3. Berichte der naturforschenden Gesellschaft zu Freiburg i.B. Vols. iii., iv.
4. Berichte der Oberhessischen Gesellschaft für Natur-und Heilkunde. No. 27.
5. Berichte über die Senckenbergische naturforschende Gesellschaft in Frankfurt a. M. 1889.
6. Berichte der Königl. Sächs. Gesellschaft der Wissenschaften zu Leipzig. 1889, ii., iii., iv.
7. Société Imperiale des Naturalistes de Moscou : Mémoires vols. i.—v. Nouveaux Mémoires : vols. i., iii., vi., vii., ix—xv. Bulletins : 1829, 1830, 1837—50, 1852—55, 1857, 1859—87, 1889.
8. Bulletin of the Museum of Comparative Zoology, at Harvard College. Vol. xvi., Nos. 6—8, xvii., Nos. 4—6. Vol. xviii. Vol. xix., Nos. 1—4. Vol. xx, No. 1—Memoirs vol. xiv., No. 1.—Annual Report, 1888—89.
9. United States Commission of Fish and Fisheries. Part xiv. Report of the Commissioner for 1886. Washington, 1889. The Fur Seal and other Fisheries of Alaska. Bulletin, vol. vii.
10. Bulletin Scientifique de la France et de la Belgique. Tomes xx., xxi., xxii., 1re partie. 1889—90.
11. Fishery Board for Scotland. Seventh Annual Report (1888).
12. Journal of the Marine Biological Association. N.S. Vol. i., Nos. 2 and 3.
13. Life-Lore. August, 1889 to February, 1890.
14. Math. u. naturw. Mittheilungen aus d. Sitzungsber. d. königl. preuss. Akademie der Wissenschaften zu Berlin. October, 1889—April, 1890.

15. Bihang till Kongl. Svenska Vetenskaps—Akademiens Handlingar. Bandet xii., Afd. 3 and 4. Bandet xiii., Afd. 3 and 4.
16. Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome xxx., 2e partie.
17. Mémoires de la Société Zoologique de France. Tome ii., iii., 1re partie. Bulletins de la Société, etc. Tome xiii., No. 10. ; T. xiv. ; T. xv., Nos. 1 and 2.
18. (*a*) Proceedings and Transactions of the Natural History Society of Glasgow. Vol. ii., part 2 ; vol. iii., part 1.
    (*b*) Transactions of the Glasgow Society of Field Naturalists. Sessions 1873—74 ; 1877—78.
19. Proceedings of the Academy of Natural Sciences of Philadelphia. 1889 parts 1, 2 and 3.
20. Proceedings of the Birmingham Philosophical Society. Vol. vi.
21. Proceedings of the Canadian Institute, Toronto. 3rd ser. Vol. vii. No. 1. Annual Report, 1888—89.
22. Proceedings of the Royal Physical Society, Edinburgh. Sessions 1887—88 ; 1888—89.
23. British Museum (Natural History). Guides : General ; Shell and Starfish ; Reptiles and Fishes ; Humming Birds ; Mammalia ; Fossil Fishes ; Geology and Palæontology ; Mineral Gallery. Students' Index to the Collection of Minerals. Introductions : Study of Minerals ; Study of Meteorites.
24. Scientific Transactions of the Royal Dublin Society. Ser. 2. Vol. iv., Nos. 2—5. Scientific Proceedings. Vol. vi. (N.S.), parts 3—6.
25. Transactions and Annual Report of the Manchester Microscopical Society. 1889.
26. Verhandlungen der k.k. zoologisch-botanischen Gesellschaft in Wien. Jahrgang, 1889, and 1890, No. 1 and 2.
27. Verhandlungen des naturhist. Vereines der preussischen Rheinlande xlvi. Jahrgang, 1, Hälfte.
28. Videnskabelige Meddelelser fra den naturhistoriske Forening i Kjobenhavn. 1884—86 ; Festskrift i Anledning af den naturhist. For. Bestaaen fra 1833—83.
29. Det Videnskabelige Udbytte of Kanonbaaden "Hauchs" Togter. No. 2.
30. Atti della Reale Accademia delle Scienze Fisiche e Matematiche. Napoli. Ser. 2a. Vols. i., ii., and iii. Rendiconto dell' Accademia delle Scienze Fisiche e Matematiche. Napoli. Ser. 2a. Vols. i., ii., iii., and iv., fasc. 1—4.
31. Studies from the Biological Laboratory, Johns Hopkins University, Baltimore. Vol. iv., Nos. 1—6. Circulars, vol. ix., No. 80.
32. Bulletins de l' Academie Royale de Belgique. 3me sér. Tomes xiv—xvii.

Annuaire de l' Acad. Royale de Belg. 1888. 1889.

33. Memorie della R. Accademia delle Scienze dell' Istituto di Bologna Scienze Naturali. Ser. 4 T. vii.—ix. Medicina e Chirurgia, ser. 4, T. vii.—ix.

34. Mémoires de la Section des Sciences. Académie des Sciences et Lettres de Montpellier. Tome xi., 1re fasc.

35. Forhandlinger i Videnskabs—Selbskabet i Christiania. 1886—88.

36. Studies from the Biological Laboratories of the Owens College. Vol. i.

37. (*a*) Annual Reports of the Smithsonian Institution. 1886 and 1887.
(*b*) Proceedings of the United States National Museum. Vols. ix—xi. 1886—88.
(*c*) Bulletin of the U.S. National Museum. Nos. 34—37.

38. Procès—Verbaux de la Société Linnéenne de Bordeaux. Vol. xli. 1887.

39. Proceedings of the Royal Society of Edinburgh. Nos. 123—128. Session 1886—87 ; 1887—88 ; 1888—89.

40. Bulletin des Séances de la Société des Sciences de Nancy. 1re année. Nos. 3—5.

41. Natuurkundig Tijdschrift voor Nederlandsch—Indië. Deel xlviii. 1889.

42. (*a*) Kgl. danske Vidensk. Selsk. Skriftr, 6 te Række, naturvidenskabelig og mathematisk Afd. 4 de Bd. i., iv., vi., 5 te Bd. i.
(*b*) Oversigt over det Vidensk. Selsk. Forhandlinger. 1886-87; 1890. No. 1.

43. Proceedings of the Boston Society of Natural History. Vol. xxiv., parts 1 and 2.

44. Bolletino della Società Adriatica di Sienze naturali in Trieste. Vol. xii. 1890.

45. Travaux de Zoologie appliquée. Station Zoologique d'Endoume (Marseille). 1re année. 1889.

46. Transactions of the Royal Society of Victoria. Vol. i., part 2. 1889.

The following donations have been received :—

1. Types of Metamorphosis in the development of the Crustacea. By I. C. Thompson, F.L.S., F.R.M.S. Presented by the author.
2. Observations on the fertilisation of certain species of Saxifraga. By J. J. Ogle. Presented by the author.
3. Handbook for Southport. Presented by Mr. A. Leicester.
4. Arbeiten der zool. Section für Landesdurchforschung von Böhmen. Vol. i., 4 ; vol. ii., 4 ; vol. iii., 4 ; vol. vi., 2 and 5. Presented by Dr. Anton Fritsch.
5. Principien d. Organisation d. naturh. Abth. d. neuen Museums zu Prag.—Saibling-und Forellenzucht.—Elblachs.—Führer, geolog. Sammlung in Prag. By Dr. Anton Fritsch. Presented by the author.

THE LIVERPOOL BIOLOGICAL SOCIETY,

Dr. In Account with ISAAC C. THOMPSON, Hon. Treasurer. **Cr.**

1890.	£	s.	d.	1890.	£	s.	d.
To Gas and Attendance, University College	3	0	0	By Balance, 30th June, 1889	46	1	1
,, Tea and Attendance at Meetings	6	3	8	,, 4 Members' Entrance Fees at 10/6	2	2	0
,, Printing and Stationery, Turner, Routledge & Co.	96	5	0	,, 9 Student Members' Entrance Fees at 2/6	1	2	6
Do. F. Huth	1	1	0	,, 58 Members' Subscriptions at 21/-	60	18	0
Do. T. Dobb & Co.	1	0	0	,, 38 Student Members' Subscriptions at 5/-	9	10	0
Do. Various	0	3	6	,, Sale of Proceedings	1	13	6
,, Embossed Stamp, Yates & Hess	1	16	6				
,, Carriage and Postage of Books, Reports, &c.	5	12	5				
,, Postages, various	1	13	0				
,, Balance in hand, 30th June, 1890	4	12	0				
	£121	7	1		£121	7	1
				By Balance in hands of Treasurer	£4	12	0

ISAAC C. THOMPSON,
Hon. Treasurer.

Audited and found correct,
ALFRED LEICESTER.

Liverpool, 30*th June*, 1890.

OPENING ADDRESS

TO THE

LIVERPOOL BIOLOGICAL SOCIETY.

By Professor W. A. Herdman, D.Sc., President.

[Read 11th October, 1889.]

Contents.

Position of the Society.

I must first thank you very heartily for having elected me a second time to occupy the presidential chair, and I hope that the session which we are now commencing will be a very prosperous one with the Liverpool Biological Society. Prosperity in the case of a scientific society does not depend so much upon the number of members on the roll as upon the energy with which the affairs are conducted and the interest and value of the publications as contributions to knowledge. Judged by this standard our Society may fairly be regarded as having already achieved a considerable measure of success. Our annual volume of "Proceedings" (1888-89) is again this year larger than its predecessor, and the papers it contains are quite as important as any we have previously issued.

As a practical testimony to the value of our "Proceedings" we have the fact that our volumes have been accepted by about thirty of the leading Continental Societies of Natural Science in exchange for their own publications. The establishment of this exchange list, which was effected during last session, is a distinct step in advance, and is calculated to benefit us in two ways. In the first place it secures the circulation of our papers abroad in the very quarters where they will be most useful and most appreciated, and in the second place it brings to us a valuable series of foreign publications which we might otherwise have some difficulty in getting access to. The importance of this last fact to our workers will be at once seen when I mention that already the library contains 527 books and pamphlets received in exchange for our three first volumes of "Proceedings."

Now I am recounting these proofs of our Society's favourable position not with a view of inducing any feeling of self-satisfied complacency, which would be fatal to further advance; on the contrary it is with the object of rousing all the members of the Society to fresh efforts by the consideration that if we do our duty we have the possibility of a grand future before us. It is true of a scientific society, as of many other organisms and institutions, that to stand still is impossible. If there is no advance there must be retrogression. Personally I shall use my best endeavours to make this coming session one of active advance, and I know that my efforts will be most ably supported by my colleagues on the council, but I am anxious to induce every individual member to take such a personal interest in the affairs of the Society as will ensure our rapid progress towards a higher level of usefulness and a wider sphere of operations; and there are three heads under which I would indicate what we can each and all of us do for the common good, and these are—the *number*, the *attendance*, and the *work* of our members.

Our Society is increasing each session, but still the number on our roll of membership ought certainly to be doubled or trebled. The science of Biology is rapidly growing in popular favour. With the acceptance of the theory of Evolution as a doctrine applicable not merely to plants and animals, but also to history, theology, politics, and all other departments of human thought, it has been recognised that biological principles and biological methods are of wide application and should form an important element in a liberal education. Consequently the work of a biological society ought, if conducted on a broad basis, to excite a wide-spread interest and receive the support of a large proportion of the community. Then in a great centre like Liverpool there are many whose professional, business, or other pursuits, bring them into touch with some department of Natural History. Doctors, dentists, chemists, agriculturists, entomologists, are all alike biologists, and should find some common scientific ground in the meetings of a biological society which is not too highly specialized—not too restricted in its scope. And I can assure you that your Council is very desirous of making this Society as useful and instructive as possible to biologists of every persuasion.

There is then, I believe, plenty of material around us for the formation of a very much larger Society, and what is evidently required is that we should all make it a personal matter to find out those interested in any branch of biological science and to bring them speedily within the pale of our community.

The second point requiring notice is the attendance at the meetings, and this is a matter which merits our most careful consideration, for every one will admit that it is most desirable for as large a proportion as possible of the members to attend regularly and take part in the proceedings. In the first place it seems quite impossible to fix upon a time of meeting which will be convenient for every one, and apparently our present night and hour are those which suit the majority of the members of the Society.

The further question then arises, Are our proceedings at the meetings as satisfactory and instructive as we can make them?—and here I would like to speak perfectly frankly and without reserve, but I am expressing my individual opinion only, and my remarks must not be taken as implicating or binding the Council in any way.

Procedure at Meetings.

There are two chief classes of papers which are offered to societies such as ours.

First, there are the more or less popular expositions of some subject already known to science. Such essays if well prepared are usually entertaining and sometimes instructive to listen to, but they are dangerous. They should—remember I am expressing my own opinion only—they should on no account be published in the volume of "Proceedings."* They at once stamp the society which issues them as wanting in originality and in power of investigation or research. I would not however go so far as to prevent such papers, when dealing with sufficiently important subjects, from being read at the meetings; on the contrary I think they occasionally form a very good introduction to an interesting and instructive debate, but they must be used in moderation, not more than say two or three being allowed in a session, and they must be

* I intend to propose at an early meeting of the Council that in future the Society should publish (1) "Proceedings," giving an abstract of all that occurs at the meetings, and also (2) "Transactions," containing the original papers of importance printed in full. If this plan is adopted any popular addresses or expositions and discussions brought before the Society would be appropriately mentioned in the Proceedings although not printed in the Transactions.

carefully watched, for this kind of paper has a decided tendancy to reproduce rapidly—one popular exposition leads to another, and it may be if not carefully guarded against to half-a-dozen others, and the scientific taste of the society becomes depraved. I am inclined to think that the downfall or degradation of not a few provincial scientific societies could be traced to a too liberal indulgence in popular lectures and expositions.

The second form of paper is the strictly scientific but exceedingly uninteresting and even sometimes incomprehensible account of some special point, dealing it may be with lists of species or with the details of structure of some obscure organ. Such papers being original research are extremely valuable, but require to be carefully studied. Even a specialist can rarely appreciate them when he hears them read for the first time. They should be published in the annual volume, and they reflect credit upon the society which produces them, but I submit that they are not suitable for reading at the meetings. The author of such a paper should I think be requested to hand his manuscript over to the secretary for publication, while at the meeting he should with the aid if possible of a few diagrams, or of the black-board and chalk, give in the space of about quarter to half-an-hour an intelligible account of what his paper is about, commencing with a few introductory remarks for the purpose of bringing the general biological knowledge of his audience up to the point where his special research began, and then explaining without going into unnecessary detail what it is that he has found out, and what bearing his discovery has upon other biological problems.

A paper may occasionally turn up which is strictly original and at the same time is perfectly intelligible and interesting. Of course such a one might with great advantage be read in full to the meeting. As to the reception with which a paper meets when read, I think there is often room for improvement. Although it is not advisable that the proceedings at all scientific meetings should be as lively as those of famous memory, which broke up the "Society upon the Stanislaus," as immortalised by Bret Harte, still discussion—kept within proper bounds—is a very good thing; and a condition of mind similar to that of Abner Dean of Angel's, when—

> "The subsequent proceedings interested him no more,"

is, at least in our old world civilization, not so frequently the result of a violent discussion, as of an entire absence of any intelligent difference of opinion and of any natural curiosity on the part of the audience. It is often most stimulating and useful to an author of a paper to have his results questioned and his methods criticised, and if a paper is so special that no one can criticise it except a specialist, well, at least we can all ask questions about those points we have not understood. And no one should ever be ashamed to ask questions at a scientific meeting.

During last session I introduced the plan of inviting, as your President, two or three well-known biologists from other towns to address us, not necessarily with a view to publication, on the subjects upon which they happened to be working at the time. I think it to be a useful plan, and, with your permission, I shall repeat it during this session, by getting one or two outside biologists to come and tell us about their present work. It helps to keep us in touch with the world of investigators in London, Edinburgh and elsewhere, and may throw fresh light upon some of our own work and possibly prevent our getting fixed in some undesirable grooves.

By arranging then for a couple of such addresses, and for one or two discussions upon points of biological interest, and by having our more technical papers explained briefly by the authors, in place of being read, we could, I think, without losing our scientific standing or in any way changing the character of our publications, make the meetings more attractive and instructive, and so I hope induce our members to attend in larger numbers and take a more lively interest in the proceedings.

Original Work.

To pass now to our third head, the work of our members, although we have ever since the formation of the Society justly prided ourselves upon its eminently practical nature, upon the large amount of original investigation which is brought before it by the members, yet we ought not to rest satisfied, for research is the life and soul of a society, and should be encouraged in every possible way, and wide fields for work in many departments of biology still stretch around us. This is a matter in which perhaps some of us who have had more opportunity of studying biological methods may be able to help our fellow members by suggesting subjects for research and lines of investigation; and, as I pointed out in my presidential address of last year, by far the most important and interesting investigations requiring the attention of biologists at the present time are those which have a bearing upon the theory of evolution.

Physiological Selection.

Some of you will, doubtless, recollect that in that address, while discussing Dr. Romanes' theory of physiological selection, I quoted Professor Fleeming Jenkin's imaginary case of a white man wrecked upon an island inhabited by negroes, given as an illustration of the supposed swamping effect by free intercrossing of a marked variety with the parent species. I then went on to say* in criticism of the result at which Jenkin arrived, viz. that the characteristics of the white man would be stamped out by intercrossing with the black:—

"Two influences have, I think, been ignored, viz. atavism, or reversion to ancestral characters, and the tendency of the members of a variety to breed with one another. Keeping to the case described above, I should imagine that the numbers of intelligent young mulattoes produced in the second, third, fourth and few succeeding generations would to a large extent intermarry, the result of which would be that a more or less white aristocracy would be formed on the island, including the king and all the chief people, the most intelligent men and the bravest warriors. Then atavism might produce every now and then a much whiter individual—a reversal to the characteristics of the ancestral European—who, by being highly thought of in the whitish aristocracy, would have considerable influence on the colour and other characteristics of the next generation. Now such a white aristocracy would be in precisely the same circumstances as a favourable variety competing with its parent species," &c.

You may imagine then my pleasure when a few months after writing the above I accidentally found in a letter† written by the celebrated African traveller Dr. David Livingstone to Lord Granville, and dated "Unyanyembe, July 1st, 1872," the following passage :—

"About five generations ago, a white man came to the highlands of Basañgo, which are in a line east of the watershed. He had six attendants, who all died, and eventually their headman, called Charura, was elected chief by the Basañgo. In the third generation he had sixty able-bodied spearmen as lineal descendants. This implies an equal number of the other sex. They are very light in colour, and easily known, as no one is allowed to wear coral beads such as Charura brought except the royal family. A book he brought was lost only lately. The interest of the case lies in its connection with Mr Darwin's celebrated theory on the 'origin of species,' for it shows that an improved

* Proc. Biol. Soc., Liverpool, vol. iii., p. 6, 1889.

† In Appendix to H. M. Stanley's "How I Found Livingstone," 2nd ed. London, 1872; see p. 715.

variety, as we whites modestly call ourselves, is not so liable to be swamped by numbers as some have thought."

Here we have a perfect fulfilment of what I last year, in ignorance of this observation of Livingstone's, predicted as being likely to occur in such a case. We have the whitish aristocracy in a dominant condition, and evidently in a fair way to spread their characteristics over a larger area and give rise to a marked variety, and it had clearly struck Livingstone fourteen years before the theory of physiological selection had been heard of, just as it must strike us now, as an instance telling strongly against the "swamping" argument as used by Fleeming Jenkin and Romanes.

Transmission of Acquired Characters.

At the meeting of the British Association held at Newcastle last month, two important discussions took place in Section D (Biology) upon subjects connected with Evolution which, although they did not lead to any definite conclusions at the time, must have done good in allowing the views of various schools of evolutionists to be thoroughly ventilated. The first of these discussions was upon the vexed question of acquired characters—Can a character acquired as the result of external influences during the lifetime of one generation be transmitted by heredity to the next generation?

Nearly all evolutionists hold by some form of the Weismannian theory of heredity, and according to Weismann it is theoretically impossible for an acquired (or "somatogenic") character to be inherited,* because the

* "Hence it follows that the transmission of acquired characters is an impossibility, for if the germ plasm is not formed anew in each individual but is derived from that which preceded it, its structure, and above all its molecular constitution, cannot depend upon the individual in which it happens to occur,

body of the new individual is formed from germ plasma which is derived from the germ plasma of the parent, and has nothing to do with the parent's body, which was distinguished by the acquired character, except that it lay in that body (or somatoplasm).* But if any day an experimental biologist should be able to prove that a single acquired character had been transmitted to the offspring, and Mr. Francis Galton has just suggested† some experiments which seem practicable and very suitable for settling the question, and which might give some day a positive result, then that one fact would outweigh any amount of theory, and it would be necessary for us to revise our ideas in regard to heredity.

Consequently it would be very satisfactory to those biologists who are inclined to accept Weismann's theory of the continuity of the germ plasma, but at the same time would admit the possibility of acquired characters being sometimes transmitted, if a loophole could be found in the theory which would allow of the germ plasma being impressed by an acquired character, and for my own part I do not see any great difficulty in the way. The germ plasma, it must be remembered, lies in the somatoplasm or body plasma and is surrounded by and in intimate histological connection with the body which has the acquired character—it is nourished by and is in complete physiological communication with that body. Therefore

but such an individual only forms, as it were, the nutritive soil at the expense of which the germ-plasm grows, while the latter possessed its characteristic structure from the beginning, viz. before the commencement of growth."—(*Essays upon Heredity, &c.*, by Dr. August Weismann, authorised translation, Clarendon Press, Oxford, 1889, Essay v., p 266.)

* Weismann, however, admits that the germ plasma lying in the somatoplasm may be influenced by external conditions so as to give rise to "blastogenic" characters in the next generation (loc. cit. p. 410).

† To Section D, at Newcastle meeting of British Association, Sept., 1889.

it seems probable that any strongly marked acquired character could scarcely fail to produce some effect upon the germ plasma lying in the body, and the only question then is whether the effect produced would give rise to a corresponding character in the next and succeeding generations, or whether the effect might not merely be of the nature of a general change such as increased or diminished nutrition. At any rate there seems enough doubt here to allow of a loophole in the "continuity" theory whereby an acquired character might leave its impress upon the germ plasma and so be transmitted to the next generation.

The Utility of Specific Characters.

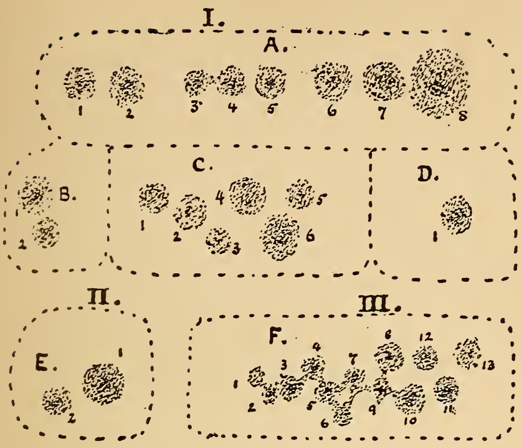
The second discussion in Section D. of the British Association was upon the utility or indifference of specific characters, that is—Are the characters by which allied species differ from one another of such a nature as to be actually useful to their possessors, or are they so trivial as not to affect in any way the welfare of the species? And I wish to direct your attention to this matter in some detail, as it opens up a wide field for original research—dealing as it does with the characters both physical and psychological of all animals, and seeking an explanation for many peculiarities of structure and habit.

The solution of this wide question in regard to specific characters can only be settled I hold by an appeal to facts. Competent observers, specialists in the various groups of plants and animals, who are intimately acquainted with the various forms, must investigate a number of allied species, not as museum specimens only but in a state of nature, and must observe their habits carefully in order to determine whether there is any relation between the characters by which the species differ from one another and the observed mode of life.

This as you can see will be a very large piece of work, as it involves a re-examination of all accessible species in a state of nature, but it is an investigation well worth making. It will give a new and very real importance to faunistic and speciographic work, and it will be greatly aided by the numerous biological stations which are being established on the coasts of Europe and America, as by means of these institutions it has now become possible for the first time to work satisfactorily at marine animals in a living state. Moreover this work if properly carried out will lead to a careful revision of the specific characters of allied forms in many groups of animals, in itself a very desirable object, for all systematists know how much the specific characters of some groups are in need of revision.

The definitions of most genera and species are pre-Darwinian, if not in date at least in conception. Genera and species have been regarded by most systematists as sacred and immutable things, and moreover as being totally different from one another, but we now know as evolutionists that a genus is only a greater or more emphasized species—that is to say, it is only an assemblage of individuals which have become more widely separated morphologically from their fellows (see the accompanying diagram). Consequently, there can be no important difference in kind between specific and generic characters.

It has sometimes been said that specific characters may be useful to their possessors, but that generic characters need not be so ; that I cannot allow. Generic characters being as it were emphasized specific characters, if the latter are useful the former must be still more so, and the same argument applies to the characters of families, and other larger groups.



Explanation of Diagram illustrating the relations between Families, Genera, Species, Varieties and Individuals.

Each dot in the clusters represents an individual, and distance apart is supposed to indicate degrees of difference in characters. The dotted boundary lines enclose genera, and I. II. III. indicate families.

Family I. has four genera, A. B. C. and D. A. is a genus with eight species (or aggregations of more or less similar individuals) arranged in three groups. In such a case some systematists might break A. up into three allied genera. Species 3 and 4 are shown as almost continuous groups of individuals; they are closely allied species, and some systematists would say that they form merely two varieties of the same species: 8 represents a larger species with many individuals. B. C. and D. are three allied genera only a little more separated from one another than the three groups of species in A. in the line above. B. has two closely allied species. C. has six distinct species. D. is a genus formed for a single isolated species.

Family II. is a small isolated group of two species forming one genus E.

Family III. comprises a number of closely allied species, most of which (1-10) are so variable and so closely related that it would become a matter of opinion amongst systematists whether they ought to be regarded as all distinct species or as varieties of one large variable species.

All these groupings of individuals have been produced as the result of evolution by the action of natural selection (along with, it may be, some supplementary secondary factors such as sexual selection, use and disuse, direct action of the environment and physiological selection), and consequently I believe that their characters will be found to be such as could be seized hold of and perpetuated by the action of natural selection. But great care must be taken in this inquiry that the true generic and specific characters are dealt with. It often happens in systematic work that we find a particular generic or say specific character, or combination of characters, to be useless, i.e. not really diagnostic of the species. It is perhaps common to many species, or it may be is not of constant occurrence. It becomes necessary then to change our ideas in regard to that species, to re-define it or even to abolish it. Such necessary changes in the recognized specific characters frequently take place during the revision of a group. Consequently, in the proposed inquiry into the usefulness or the reverse of specific characters it will not do merely to take the specific characters now published in the books on the subject. It will be necessary to subject the species in question to a rigorous examination and to re-determine their specific characters; and this while adding to the labour will add greatly to the value and interest of the work.

But it will not be sufficient to examine the adult animals alone. In some groups at least it will be necessary to investigate the whole life-history, and to study especially those stages when the young animal leads an independant life. We know that in many such cases large and remarkable larval structures are formed which are of very great importance to the possessor during a brief period of its existence, and are then usually got rid of in some way; but I strongly suspect that in some cases the apparently useless and mysterious structural features of the adult animal may be explained as the remains of, or as having been caused by the presence of, useful larval structures. If that is the case, then we may have some specific characters which although not actually useful themselves are the representatives of the useful structures of a younger stage, and would therefore be maintained in each generation by the action of natural selection. This is a point to which I would especially direct the attention of those of our members who study the Crustacea. In that group there are many larval stages living under very varied conditions and possessing often remarkable larval structures which probably have some influence upon the form and other characteristics of the adult body.

Dr. Romanes, in the paper with which he opened the discussion upon specific characters at the British Association, described the method which he had adopted in judging of the relative utility of the specific characters in the cases of some species of kangaroos. He placed the specific characters as given in the British Museum Catalogue of these animals in one of two columns, according as they seemed useful or indifferent in their nature, and he found that the column containing the indifferent characters was the longer one. But this method I hold will not give satisfactory results, because while the one column, that of the useful characters, gave positive results, the other column only gave negative results, i.e. it contained those characters in regard to which we do not yet know whether they are useful or not, and I would anticipate that as time and investigation went on, and we came to know the habits and the mode of life of the animals more minutely, character after character would have to be transferred from the negative to the positive column, and that is why I say that the matter must be settled by an appeal to investigators, and by a search for fresh facts, and one of the very best fields for investigations of this nature lies amongst the Marine Invertebrata.

Most writers upon evolution, following the example of Darwin and Wallace, have taken their examples from the higher animals—generally from the mammals and the birds, with the addition of insects. Consequently, most groups of the Invertebrata still present a virgin field for this department of evolutionary study.* I have commenced during the last couple of years some observations upon the nature of the diagnostic characters in the Nudibranchiate Mollusca and the Tunicata, and I shall now give you some examples from these groups in support of my views.

Nudibranchiata.

Let us take the Nudibranchiata first, and here one is at once met with by the difficulty of determining what the true specific characters are. If we turn to our great English work of reference, Alder and Hancock's Monograph of the Nudibranchiata, published by the Ray Society, we find that the shape, number and colour of the various projections from the body and other similar external features are employed as the diagnostic characters; while in the works of Dr. Rudolph Bergh, the greatest living authority on Nudibranchs, and the author of the "Challenger" Report, the specific descriptions contain detailed accounts of the anatomy of all the important organs of the body, which are admirable contributions to knowledge, but do not single out for us those salient

* Which is to a large extent that aspect of Zoology to which Ray Lankester has applied the term "Bionomics." Ency. Brit., 9th Ed., Art. Zoology.

points, whether of external appearance or of internal anatomy, which sufficiently distinguish allied species from one another.

Evidently there is still a great deal of critical work to be done in the examination and diagnosis of the various species of Nudibranchs, but there can be little doubt that in at any rate very many of the species, characters derived from the external appearance as given by Alder and Hancock will figure amongst the revised specific descriptions, and the question then arises, Can we account for the varied shapes and colours of the curious horn-like and often dendritic projections from the bodies of Nudibranchs on the ground of utility? And I believe we can, as the following few instances will show you.

In *Tritonia* (or *Candiella*) *plebeia*, in addition to the rhinophores or smelling tentacles near the anterior end of the animal, we find a series of small branched projections called "cerata" placed along each side of the back. These are not branchiæ, but are merely outgrowths from the body wall. This species is fairly abundant at Puffin Island and at Hilbre Island, and is found in those localities creeping over the surface of colonies of *Alcyonium digitatum*. The specimens of *Tritonia* are marked with many colours, including tints of yellow, brown, blue, grey, black and opaque white; and when examined in a vessel by themselves considerable differences between individuals are noticed, but when in their natural condition on the *Alcyonium* colony they are nearly all equally inconspicuous.

The colonies of *Alcyonium* differ considerably amongst themselves in tint, some being whiter, others greyer, and others yellower than the rest; different parts of the same colony also vary in appearance on account of the different states of expansion of the polypes, and on account of irregularities of the surface, and of adhering sand and mud; so that the varieties of colouring found in the *Tritonia* are suited to the various conditions of the *Alcyonium* colonies. The small branched cerata along the back of the *Tritonia* aid the protective resemblance not only by contributing to the general colouring, but also by their similarity in appearance to the crown of tentacles of the partially expanded polypes. They are placed at just about the right distance apart, and have the necessary tufted appearance.

Then again, *Doto coronata* when isolated is a very conspicuous and highly coloured animal, but we find it at Hilbre Island almost invariably creeping on the under surfaces of stones on which are large colonies of the Zoophyte *Clava multicornis*, and in that position the *Doto* is not readily seen. The gay appearance of this Nudibranch is mainly due to the large and highly coloured cerata, and these agree so closely in their general effect with the upper ends of the zooids of *Clava* covered with their numerous tentacles and the clusters of sporosacs, that when the *Doto* remains still it is hidden to a very remarkable extent.

Dendronotus again, with its very large branched cerata (evidently a further development of the small processes of the body wall seen in *Tritonia*) and its rich purple-brown and yellow markings, is a handsome and most conspicuous object, but I have sometimes found it amongst masses of brown and yellow Zoophytes and on purplish red seaweeds, where it was very completely protected from observation, and I did not for several seconds recognise what I was looking at.

Now these are all cases where the colouring is protective, and I have no doubt there are many other similar instances to be found amongst the Nudibranchiata, but the species of *Eolis* appear to be in a different category. They are noted for the very brilliant hues of their cerata, and they are always conspicuous so far as I have noticed, even in their natural condition. Then again the species of *Eolis* are rarely found hiding in or on other animals, they are not shy, and they are active in their habits—altogether they seem rather to court observation than to shun it. When we remember that the species of *Eolis* are protected by the numerous stinging cells in the cnidophorous sacs placed on the tips of all the dorsal cerata, and that they do not seem to be eaten by other animals, we have at once an explanation of their fearless habits and of their conspicuous appearance. The brilliant colours are in this case of a warning nature, for the purpose of rendering the animal provided with the stinging cells noticeable and recognisable.

Upon such cases as these then I base my view that the chief function of the cerata of these Nudibranchs is by varied shapes and colours to enable the animal to assume appearances which are in some cases protective and in other cases conspicuous and warning, according as may be found best suited to the surroundings and mode of life, and in this it seems to me we have an explanation of the extraordinary development of these otherwise mysterious processes of the body wall. If this is the correct interpretation, it affords us marked examples of real utility in specific characters which may at first sight appear to depend upon trivial differences in form and colouring.

Tunicata.

Turning now to the Tunicata, we come to a group at which I have been working for a much longer time, and in which I found it necessary to set to and re-determine for myself the true diagnostic characters of many of the species and genera. Most of the older descriptions of the species of Tunicata consisted merely of a short account of the external appearance of the animal; but it is quite absurd to attempt to describe or even in most cases to identify an Ascidian without dissection and microscopic examination. As Savigny long ago said,* "Les Ascidies ont l'organisation variée et l'aspect uniforme. La configuration qui leur est affectée ne permet pas que les différences intérieures se manifestent au-dehors par des signes fort sensibles. Aussi les distinctions nécessaires à la parfaite connaissance des espèces sont-elle difficiles à tracer."

In some cases the genus and even sometimes the family cannot be determined without dissection. For example, in many museums and other collections, all Simple Ascidians which are incrusted with sand and shell fragments are labelled "*Molgula*," but some of these specimens usually belong to the genus *Eugyra* (to distinguish which the branchial sac ought to be examined microscopically), and in some cases they belong to *Polycarpa*, a member of a different family, the Cynthiidæ, and they may even be Ascidiidæ (e.g. *Ascidia involuta*, Heller). It is even possible that such forms might be Compound Ascidians, as *Polyclinum sabulosum* and various species of *Psammaplidium* are incrusted with sand, and in external appearance mimic the Molgulidæ. Consequently most of the older descriptions of Ascidians are of little or no value; they frequently give no clue even to the genus to which the species belonged.

It is clear then that the internal structure or anatomy of the animal must be considered in diagnosing the species of Tunicata, and the important question then arises—Which organs are of greatest importance in distinguishing allied species? All recent investigators of the Tunicata are agreed in fixing upon certain important organs, such as

* Mémoires sur les Animaux sans Vertèbres, Pt. ii., p. 84, 1816.

the branchial sac, the tentacles, the dorsal lamina, as those which yield the most reliable characters. Now, these organs have prominent rôles to fill in the life of the animal in connection with nutrition, respiration, the circulation of water through the body, and the collection and agglutination of food particles, and any changes in their size, form and structure must be of considerable physiological importance. And I find that in going over the characters of species of Ascidians, I can recognise a marked utility in the various specific modifications of these and other organs. Even the very varied external shapes may be regarded as useful modifications, since they allow of, and correspond to, particular forms of the muscular mantle and the branchial sac and the other viscera within the test, and of course the shapes of the mantle and branchial sac are of great functional importance, since they have to do with the animal's respiration and the regulation of the food supply.

Even in the case of such apparently trivial characters as the shapes and distribution of the minute spicules of carbonate of lime throughout the colonies of *Leptoclinum* and some other Compound Ascidians, I know from experience that they affect the hardness and roughness as well as the colour of the colony, and so may be of considerable importance in repelling enemies and in keeping the colony free from injurious parasites. As a matter of observation I find that the colonies of Didemnidæ (which are provided with calcareous spicules) are much freer from both external and internal parasites than are the softer-bodied Compound Ascidians.

Passing to the interior of the body of the Ascidian we find that the current of water pouring in at the branchial aperture, through the stigmata in the walls of the branchial sac into the atrial cavity, and from that out by the atrial aperture, is of primary importance since it serves the following purposes:—

(1) it conveys oxygen into the body for respiratory purposes;

(2) it brings the food matters into the body;

(3) it removes waste matters from the body, and

(4) it conveys to the exterior the ova and spermatozoa.

This current of water is caused and guided by (*a*) the shape of the mantle and the arrangement of the sphincters and other muscles, and (*b*) the cilia covering certain of the vessels and other parts of the wall of the branchial sac. Hence modifications of the form of the mantle and of its muscles, and of the vessels, bars, papillæ, &c. forming the wall of the branchial sac (which are precisely the characters now made use of in describing the species) must surely be of functional importance, or in other words are useful modifications such as would be produced by the action of natural selection.

It is scarcely necessary to call attention to such important adaptive characters as the arrangement of the blood vessels and the water passages in the walls of the branchial sac, but it may be pointed out that even such trivial structures as the spine-like scales lining the branchial siphon in some Cynthiidæ may well be more or less useful according to their shape and size, in keeping out small unwelcome intruders, such as the young of the parasitic Copepoda sometimes found in the branchial sacs of some Ascidians.

Another point in which species of Ascidians differ is the condition of the tentacles round the entrance to the branchial sac, i.e. their number, shape, branches and arrangement. These organs probably perform various functions: they break up and distribute the currents of water, they intercept and guide the food particles, they probably act as sensory organs, and they form a more or less perfect grid for preventing large objects from entering the branchial sac. Hence there can be no doubt that in this case also the various modifications are really useful.

I feel that I am still only on the threshold of this inquiry, but these few instances are perhaps sufficient to show why it is that I believe that specific and generic and other diagnostic characters are of actual importance to their possessors, are in fact such adaptive modifications as would be produced by the action of natural selection; and therefore I have no hesitation in recommending this subject to you as one of the most interesting and fruitful lines of investigation in the whole field of marine Biology.

ADDITIONAL NOTES on the TERMINOLOGY of the REPRODUCTIVE ORGANS of PLANTS.

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[Read 14th December, 1889.]

During last session I laid before this Society a few suggestions on the necessity for a revision of the terminology of the reproductive organs of plants, and indicated in outline what seemed to me at that time to be the most desirable features to be aimed at in such a revision. I need not do more on the present occasion by way of resumé than briefly restate the principles on which I based my suggestions. They were briefly these :—

1. that in view of the fundamental unity of Botany and Zoology, not only in subject matter (living organisms) but also in method, it is desirable that the names, at least of the reproductive organs and of their products, should be the same in both these sub-sciences ;

2. that at present the terminology of the reproductive organs of plants was in a transitional and exceedingly unsatisfactory condition ;

3. that the terminology of the reproductive organs of animals afforded a convenient and suitable model on which any reform might be based.

I desire in the present paper (1) to make a few remarks on the system of terms which has been suggested and worked upon in the "Handbook of Cryptogamic Botany," recently published by Messrs. Bennett and Murray ; (2) to reply to various criticisms offered by Prof. T. J. Parker, F.R.S., and Mr. P. W. Myles, F.L.S., on the terminology

I suggested; and to give some further arguments by way of justifying the use of certain terms for the employment of which I have been adversely criticised; (3) and lastly, to propose certain alterations in my own scheme, which I trust may meet the approval of my critics and render the system more effective and satisfactory.

(*a*) I took occasion (with however qualified assent and approval) to refer in my previous paper to the labours of Messrs. Bennett and Murray in the subject of the reform of the terminology of the reproductive organs of plants.* Now, however, that these authors have given emphasis to their work by employing their revised terminology in their recently published "Handbook," I feel that I ought to do more than merely state in general terms that I do not consider their system altogether satisfactory.

"The first requisite in a terminology, after accuracy," say these authors, "is simplicity; and to that end we have, wherever possible, used anglicised instead of Latin and Greek forms." Following this principle, an antheridium becomes an "*antherid*," a sporangium a "*sporange*," a cænobium a "*cœnobe*," and so on. The charge of "awkwardness" and "uncouthness" brought against the "foreign forms of these words" by the authors is I think equally, if not more, valid in reference to the anglicised forms; and I am glad to find that Dr. D. H. Scott, in *Nature* (July 4th, 1889), makes precisely the same criticism. The change is also in my opinion quite unnecessary. I can see no objection to, but rather advantage in (linguistic), the use of Latin and Greek names, provided they accurately express what is intended and be accurately spelt. The authors themselves are indeed inconsistent even on this

* "A Reformed System of Terminology of the Reproductive Organs of the Thallophyta." Q. J. M. S., vol. xx.

point, else why permit "*prothallium*," "*indusium*," and such like terms to retain their primitive "uncouth" form.

I think the authors have done rightly in restricting the use of the term "*spore*." Their definition of the term is as follows:—"any cell produced by ordinary processes of vegetation, and not directly by a union of sexual elements, which becomes detached for the purpose of direct vegetative propagation." The authors then proceed to qualify this general term by certain prefixes which I cannot but think are unnecessary. "The simple term *spore* will,' they write, "for the sake of convenience, be retained in Muscineæ and Vascular Cryptogams; but in the Thallophytes it will generally be used in the form of one of those compounds to which it so readily lends itself, expressive of the special character of the organ in the class in question. Thus in the Protophyta we have *chlamydospores;* in the Myxomycetes, *sporangiospores;* in the Saprolegnieæ and many Algæ, *zoospores;* in the Uredineæ, *teleutospores, æcidiospores, uredospores,* and *sporids;* in the Basidiomycetes, *basidiospores;* in the Ascomycetes (including Lichenes), *ascospores, polyspores,* and *merispores;* in the Diatomaceæ, *auxospores;* in the Œdogoniaceæ, *androspores;* in the Florideæ, *tetraspores;* and others belonging to special groups. The cell in which the spores are formed will, in almost all cases, be called a *sporange;* and this term will be compounded in the same way as spore."

In Messrs. Bennett and Murray's definition of the term "spore" the qualifying word "directly" is obviously inserted to enable the authors to include under that category such reproductive cells as the so-called "ascospores" of the Ascomycetes and the "carpospores" of the higher Algæ. In these cases, however, as every botanist knows, the so-called "spores" in question, though not directly, are in reality indirectly products or results of sexual union. I confess I cannot see why, because the sexual process is a complicated one and the resulting products are derived only indirectly from the uniting cells, botanists fight shy of acknowledging the essentially sexual origin of these products. The question really is, are ascospores and carpospores to be considered as sexually-produced cells or are they not? If they are, why employ the suffix spore in describing them? If they are not, what is the meaning of the complicated sexual process preceding their formation? That the so-called "cystocarp" is a parasitic asexual generation is, it seems to me, by no means certain.

Further, a spore in the sense in which I understand the term, viz. a cell produced by vegetative process, and neither directly nor indirectly connected with sexual union, is surely always, at least physiologically, the same though there may be slight morphological differences consistent with the varying habit of the plant and the nature of the environment. The mode of formation of what I venture to consider true spores, certainly differs in different plants—as for example in *Mucor* and *Laminaria*, but these differences are connected with the morphological and physiological characteristics of the plant in question and surely not with the product—the spore itself.

I have always endeavoured to teach that the megaspores and microspores of the Heterosporous Vascular Cryptogams are really not spores at all, save when first formed. When ripe they are, or at least contain, structures which are multicellular and comparable to the prothallus of the Fern. How then can we employ the term spore (= cell) to a multicellular body, whether by its habit and in obedience to heredity it be enclosed within the primitive spore-cell wall or not. Both are most obviously rudimentary gamophytes.

With regard to the male organ in sexual reproduction, Bennett and Murray adopt the term "*antherid*" and "*antherozooid*" rejecting the word "*sperm*," though the recognised term in Zoology. I shall return to this point later on. Meanwhile I would merely point out that an antherozooid is physiologically and often indeed morphologically identical with the animal spermatozooid, and that there seems no reason for having two terms to indicate the same thing. "*Pollinoid*," the term used by the authors to designate what is really a motionless sperm is I think specially objectionable, more especially because, as the authors acknowledge, it is physiologically identical with antherozooid, a point the authors emphasise by using the term "*antherid*" for the cell in which the pollinoids are produced. Scott's objection to the term is also of weight, for pollinoid at once suggests pollen-grain with which the pollinoid has no relation. That some antherozoids should be motionless is a peculiarity attributable to the special conditions under which they are produced. Similar physiological peculiarities amongst the spermatozoa of animals at once suggest themselves, e.g. the sperms of most Crustacea, yet no zoologist thinks it necessary to distinguish these by distinct terms. Indeed in the Florideæ, Wright has observed amœboid motion in the "pollinoids" of *Griffithsia setacea*,* and the same phenomenon has been observed in the male cells of members of the genus *Porphyra*.

I am glad to find that there is at last some chance of the "hideous abortion oospore" being definitely ejected from botanical textbooks. I must say, however, that the term "*sperm*," which Messrs. Bennett and Murray desire to substitute for it, is, I think, in many respects even more objectionable. What is the unfortunate student to

* "On *Griffithsia setacea*." Trans. Roy. Ir. Acad., 1879.

do, when he leaves the lecture-room of the zoologist, where he has learned that the male cell in fertilization is called a sperm, and enters the precincts of the botanist, to learn that in the nomenclature of the sister science the same word stands for the product of union of the male and female cells? This objection alone is I think sufficient to put this reform (?) out of court. Moreover the term "sperm" is, not as claimed by the authors, "justified by the universal employment in phanerogamic botany of such terms as 'gymnosperm,' 'angiosperm,' 'endosperm' and 'perisperm,'" for the simple reason that used in these compounds it stands for "seed," i.e. the embryo plus its food-store and integuments, and not for "all those bodies which are the immediate result of impregnation," for which in the authors' nomenclature the word "sperm" stands. The immediate result of impregnation is not "naked" in the gymnosperms nor is the albumen within the "sperm" as the word endosperm would then signify. Although the endosperm is formed after fertilization in the angiosperm, and so might be said to be a "a result of impregnation" though not an "immediate" result, endosperm, as every student knows, is in the gymnosperm formed previous to impregnation. I am informed also by Professor Rendall, that σπέρμα in Greek stands either for "seed" in the botanical sense or "semen," and on equally good authority, so that no argument can be drawn of a distinctly favourable character from etymology.

I am bound to say that I can see no reason whatever for the persistence with which botanists cling to the term "oosphere" for the female reproductive cell. As in the case of the word spore, if the oosphere be an ovum in the sense in which that word is used by the zoologist, why not employ the term ovum in Botany also?

Finally, I cannot follow the authors in their limitation of the term Reproduction. Reproduction can have only one meaning, unless we are to be allowed to play fast and loose with all words of the kind, and that is the process of formation of a new organism from a parent or parents. That process may be a sexual or an asexual one. Indeed I would feel inclined to include under the term Reproduction all cases of gemmation, whether of such a low type as that illustrated by *Marchantia* and *Lunularia* or of the higher types illustrated by the flowering plants.

(*b*) In a recent paper by Professor T. J. Parker, F.R.S., of Otago,* some valuable suggestions on the subject of terminology are given, and certain criticisms offered of the terms I proposed in the paper already referred to. I am more than glad to find that Prof. Parker enters heartily into the arena to do battle against the archaic terminology of the textbooks, and welcome him as a powerful ally. Whilst agreeing with me on the broad principles which I laid down, he differs from me in certain details. I regard one sentence in his paper as expressing admirably the object which we in common have at heart, and it is:— "When once the homology of two structures, hitherto known by different names, whether in plants and animals, or in different groups of plants or of animals, is established beyond all reasonable doubt, the victory should be signalled by a simplification of terminology." Would that biologists would take this advice to heart!

I may now pass to Professor Parker's criticisms. He would "retain the terms *gonad* (= reproductive organ), *gamete* (= conjugating body), and *zygote* (= product of conjugation) as general terms, using the names *spermary* and *ovary* for differentiated male and female gonads;

* Proc. Australian Assoc. for the Advancement of Science, Sydney, 1888 p. 338.

sperm and *ovum* for male and female gametes; *zygospore* for a resting cell or non-motile zygote formed by the conjugation of equal and similar gametes; *zygozoospore* for a similarly formed motile zygote; and *oosperm* for a zygote formed by union of ovum and sperm."

We are at one then upon the use of the terms ovum and sperm. Ovary and spermary, I confess I do not like, (1) because the word ovary, as Professor Parker himself points out, is already in use in another and quite misleading sense (in Botany), and all biologists know how difficult it is to change the meaning of an already well recognised term; and (2) because I prefer the Latin equivalents (Bennett and Murray notwithstanding) as being applicable for discussion in all languages and not in English only. Zygospore and zygozoospore seem to me to be open to yet graver objections. I think the distinction between the condition of mobility and immobility of comparatively small consequence, as being merely a physiological peculiarity in the special group. Recent researches have left scarcely any doubt that the products known by these names, in many groups at least, e.g. the Conjugatæ, Diatomaceæ, &c. are really products of sexual union and therefore not spores in any sense.

I am inclined to agree with Professor Parker (and also with Mr. Myles) in the necessity for a word to denote the immediate product of union of the sperm and ovum, and therefore adopt the term suggested by both these biologists, viz. oosperm—a word obviously suitable in every respect, and having the additional advantage of having commended itself to embryologists like Prof. F. M. Balfour and Prof. Haddon. The cases where sexuality is apparently not differentiated are few and becoming fewer year by year as further research among the lower plants progresses. Hence I question whether these terms gonad, gamete, and zygote are actually necessary. If we *can* do without them, let us if possible avoid adding to our already grievously overloaded dictionary of terms.

Coming now to the use of the terms gamophyte and sporophyte, Professor Parker here catches me at what at first sight looks a weak point. He says, "If the terminology in the case in question is to be reformed, what we want is names which will apply equally to animals and plants. From this point of view the termination *-phyte* is obviously inapplicable, as well as the whole name *sporophyte*, since what we wish to express is the fact that the asexual generation multiplies by budding; the fact of the buds being in some cases unicellular (spores) and in others multicellular (zooids) is of quite secondary importance. I therefore venture to suggest *blastobium* for the asexual, and *gamobium* for the sexual generation; the former is equally applicable to a fern-plant or a hydroid colony, the latter to a prothallus or a medusa."

The first criticism I have to make on this suggestion is that our difficulties will be greatly increased if changes of a serious nature have to be made in zoological as well as in botanical nomenclature. My most serious criticism is, however, that plant spores are not buds in the sense in which a medusa may be so termed. Spores arise by division of the nucleus and protoplasm of a pre-existing cell. I am of course open to correction from the zoologist, but at present I fail to see that alternation of sexual and asexual stages in a plant's life-history is homologous with the at first sight similar phenomenon exhibited by some of the Hydrozoa (we are not considering of course heterogamy). Indeed I believe that "alternation of generations" in the animal world is spoken of now more correctly as metagenesis (a term Professor Parker himself uses), that is to say alternation of a sexual with a gemmiparous stage. I know of nothing comparable to the sporangium and contained spores in the life-history say of *Obelia* or other representative type of the Hydromedusæ. Indeed the metagenesis of such animal forms finds I think its exact homologue in the peculiar and abnormal phenomenon known as "apospory," illustrated by some Ferns, and artificially produced in Mosses by Pringsheim and Stahl. The process is defined by Bower* as "a transition by direct vegetative process and without the assistance of spores, from the sporophore to the oophore." Since then the homology breaks down, I would retain these two terms, sporophyte and gamophyte, as peculiarly applicable to plant life-history, and distinguish the alternation of generations in plants from metagenesis in animals.

Mr. Myles, in a review of Bennett and Murray's "Handbook," in the *Journal of Botany*,† offers a number of useful criticisms, and suggests a schema of his own. After an expression of dissent from the views of Bennett and Murray, on the anglicising of Latin and Greek names, and a congratulatory sentence on the service these authors have done "in rescuing the word spore from the inconvenient extension given it by Vines," Mr. Myles proceeds to protest against the rejection of the term "spermatozoon" and the new use of the synonym sperm as likely to produce "gratuitous confusion"—an opinion in which I heartily concur.

I am afraid I cannot follow Mr. Myles in his proposal to use the term "oön" instead of "oosperm." If oön is merely the Greek equivalent for egg, it by no means follows that it signified a fertilized egg even in that

* "On Apospory and Allied Phenomena." Trans. Linn. Soc., 2nd ser., Bot., vol. ii., pt. 14, p. 301.

† Jour. of Bot., Sept., 1889.

language. Oosperm, which however Mr. Myles is prepared to adopt, is a far preferable term, and is, as he points out, advocated by Balfour and Haddon on the zoological side. Mr. Myles then gives in brief tabular form his own system of terminology, which I here reproduce :—

1. Sexual generation ...	= oophyte	or oophore.
	Female.	Male.
2. Sexual apparatus ...	oogone (containing oospheres)	spermogone (containing spermatozoa).
3. Sexual product	oön.	

Since the publication of that review I have received a letter from Mr. Myles, in which he gives an alternative system of terms, which to my mind is much preferable. It is as follows :—

Sexual generation	gametophyte.	
	oophyte	spermophyte.
Sexual apparatus.........	oogone (containing oön)	spermogone (containing sperm).
	oosperm.	

I have no great objection to gametophyte, though why oogone and spermogone (which I feel sure would not find favour with zoologists) are preferable terms to ovarium and spermarium, I fail to see. Mr. Myles points out that oogone gets over the difficulty of possible confusion between ovary and ovarium. This risk I am willing to run, for the term "ovary" in the botanical sense is slowly but surely dropping out of use and being replaced by megasporangium. "Oön" I confess I do not like, one objection being that as used by Van Tieghem it means "oosperm." A word so ambiguous I think ought not to find a place in any terminology. On other points Mr. Myles and I are agreed.

(*c*) The following table will serve to indicate the revised scheme of nomenclature which I venture to propose :—

A. Asexual stage	sporophyte	
producing	spores	
in.........................	sporangia.	
The spore giving rise to	oosporangia	spermoporangia.
B. Sexual stage..................	gamophyte (or gametophyte)	
	oophyte	spermophyte
producing	ova and sperms	
in.........................	ovaria and spermaria.	
The product of union of ovum and sperm ...	oosperm.	

(*a*) Giving rise by embryonic fission to products which become embryos developing directly into sporophyta.

(*b*) Becoming an embryo, developing directly into a sporophyte.

In conclusion, I would venture to remind you that this subject is really of primary importance. It is not essentially a word-debate. To the teacher and student of Biology, as Professor Parker says, "the advantage of a uniform nomenclature would be immense," the tendency towards which in the present stage of our biological knowledge "none but a 'scarabæist' of the first magnitude will regret." It is another outward sign of the long looked for and much to be desired fusion in method and treatment of two departments of scientific knowledge for ages kept religiously distinct to the fatal disadvantage of both.

THIRD ANNUAL REPORT of the LIVERPOOL MARINE BIOLOGICAL STATION on PUFFIN ISLAND.

By W. A. Herdman, D.Sc., F.L.S., F.R.S.E.,
DERBY PROFESSOR OF NATURAL HISTORY IN UNIVERSITY COLLEGE, LIVERPOOL; CHAIRMAN OF THE LIVERPOOL MARINE BIOLOGY COMMITTEE, AND DIRECTOR OF THE STATION.

[Read 13th December, 1889.]

During the past year the work of the Liverpool Marine Biology Committee has been carried on actively at Puffin Island and elsewhere in the district, and has resulted in an unusually large number of events and observations worthy of record in this annual report. The first of these reports was issued after the publication of vol. i. of the "Fauna of Liverpool Bay," and the greater part of it was devoted to an account of the establishment of our Biological Station on Puffin Island; while the second annual report was largely occupied by a description of the experiments with the submarine electric light, a method which we were the first in Europe to apply to purposes of biological investigation. On the present occasion I have to report, amongst other things, upon the further development of both of these schemes, viz. (1) the publication of vol. ii. of the "Fauna," chiefly as an outcome of the work carried on at the Puffin Island Station, and (2) the additional electric light experiments which were made during the five days cruise of the s.s. "Hyæna," at the Isle of Man last Easter, and which resulted in the capture of a large number of rare and interesting crustacea.

Publications.

The first volume of the "Fauna" was published in the summer of 1886, as an Appendix to vol. xl. of the

Proceedings of the Literary and Philosophical Society of Liverpool, and also as a separate volume.* Later on in the same year the Liverpool Biological Society was founded, chiefly as a result of the L.M.B.C. investigations, and through the instrumentality of the members of that Committee, and it was then felt that this would in future be the proper scientific society before which to lay all reports upon the biology of the district. The various papers dealing with the investigations at Puffin Island and the results of the dredging expeditions have therefore been duly read before the Liverpool Biological Society during the last two sessions (1887-88 and 1888-89), and have been published in the "Proceedings" (vols. ii. and iii.).

The L.M.B.C. have now to thank the Council of the Biological Society for allowing extra copies of these reports to be printed, in order that they might be collected and issued as the second volume of the "Fauna of Liverpool Bay." This volume of 240 pages and 12 plates appeared in July, 1889, and contains sixteen articles, by ten authors, dealing with various groups, from Diatoms up to Seals and Cetaceans. It is proposed to continue this plan of publication, to communicate the papers in the first place to the Biological Society, and to issue successive volumes of collected reports upon the fauna and flora of the district as they are ready, probably at intervals of a few years.

The total number of species which we have recorded is now 1456, and of the additions in this last volume of the "Fauna" twenty-one have not been previously found in British seas, and nine (a Sponge, four Copepoda, two

* "Fauna of Liverpool Bay," Report i. London: Longmans, Green and Co. 1886. 372 pp. and 12 pls.

Amphipoda, a Polyzoon, and an Ascidian) are new to science.

In the present paper I have to add fifty species, three of which are new to British seas and three new to science.

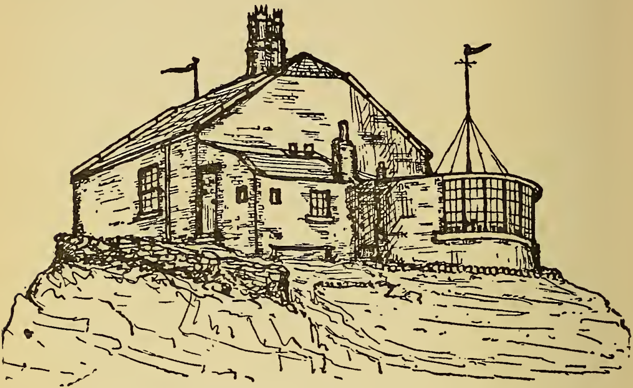


Fig. 1.—The Puffin Island Biological Station from the East.

STATION RECORD FOR THE YEAR.

During 1889 the following naturalists have worked at the Puffin Island Biological Station for longer or shorter periods:—

DATE.	NAME.	WORK.
1889.		
Feb.	I. C. Thompson, F.L.S., Liverpool	Copepoda.
—	R. J. Harvey Gibson, F.L.S., University College, Liverpool	Algæ.
—	Prof. Herdman, University College, Liverpool...	Tunicata and Nudibranchiata.
April.	R. J. H. Gibson, F.L.S., Liverpool	Algæ.
—	Dr. R. Hanitsch, University College, Liverpool.	Sponges.
—	F. Villy, Owens College, Manchester	Vermes.
—	Dr. K. Meyer, Liverpool.......................... ...	General.
May.	Prof. Herdman, Liverpool	Tunicata and general.

June.	I. C. Thompson, F.L.S., Liverpool	Copepoda.
—	J. Vicars, Bootle	Land plants.
—	A. Leicester, Southport	Mollusca.
—	Dr. Stolterfoth, Chester	Diatoms.
—	Prof. Herdman, Liverpool	Tunicata and general.
—	W. S. McMillan, F.L.S., Maghull	Copepoda and Ostracoda.
—	Dr. R. Hanitsch, Liverpool	Sponges.
—	J. A. Clubb, Liverpool	Nudibranchiata.
—	W. J. Halls, Liverpool	Hydroida.
—	R. McMillan, Liverpool	General.
—	G. Swainson, F.L.S., Bolton	General.
—	A. F. Dumergue, Liverpool	General.
July.	I. C. Thompson, Liverpool	Copepoda.
—	J. Coventry, Liverpool	General.
—	Rev. W. Houghton, Wellington, Salop	General.
—	Prof. McNab, Dublin	Land plants.
—	R. J. H. Gibson, Liverpool	Land plants.
—	R. McMillan, Liverpool	General.
—	Prof. Herdman, Liverpool	Tunicata and Nudibranchiata.
August.	J. Hornell, Liverpool	Polychæta.
—	J. Agnew, Liverpool	General.
—	J. A. Clubb, University College, Liverpool	Nudibranchiata.
Sept.	W. Cobb, M.A., Oxford	General.

The small steam launch referred to in last year's report was exchanged in April, 1889, for a useful nine-ton sailing boat, the "Bonnie Doon," a half-decked, double-bowed cutter, built like the Isle of Man fishing boats; this has been in constant use during the summer, and has proved better suited to the peculiar requirements of the locality than any other vessel we have tried. The small punt obtained in November, 1888, has been most handy for light work, and is still in excellent condition.

The room opening off the kitchen on the north side of the house (room III. in plan) was considerably improved early in spring by the insertion of a larger window, so that it is now not only more pleasant as a sleeping room, but can be used as a comfortable work room during severe weather, when the outside laboratory (with a stone floor) is too cold, and the wind is in such a direction that the stove cannot be used. The Committee propose that before next summer a simple fixed work-table running in front of the window, and a few shelves, should be put up in this room in order that it may be used regularly as an in-doors laboratory; while four or six wooden bunks erected against the wall in the adjoining room (No. II. in plan, fig. 2) would be a useful addition to the sleeping accommodation.

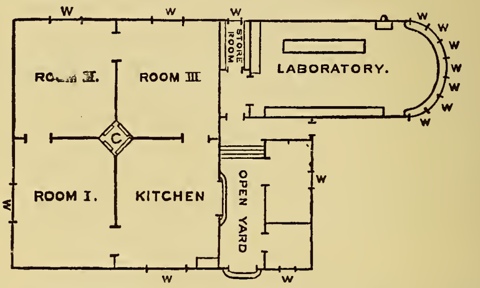


Fig. 2.—Plan of the Biological Station. W. W. windows; C. chimneys.

Condition of the Sea.

During the year, the curator (Mr. Alex. Rutherford) has continued to draw up and forward to Liverpool the weekly reports described last year, containing a careful record of the air and sea temperatures and other physical observations. From these tables it has now become possible to trace the distribution throughout the year, and the relations to temperature, of the remarkable Algæ, the appearance of which in such profusion as to cause "foul water," was first described in letters to *Nature*, in July, 1885, by Mr. Thompson from Puffin Island and the coast of North Wales, by Mr. Chadwick from Beaumaris, and by Mr. Shrubsole from Sheerness; and again, in 1886, in vol. i. of our "Fauna."* This condition of the sea has since been met with by Prof. McIntosh† in St. Andrew's Bay, in 1887, and by the naturalists at the Plymouth Biological Station, in 1889.‡ In 1885 and 1886, in our neighbourhood, the "foul water" was caused by the presence of vast numbers of small gelatinous spherical bodies containing minute spicules. During the last few years, however, this form has not been observed here, its place being taken in early summer by gelatinous masses, which are found on examination to be composed almost entirely of Diatoms, chiefly *Coscinodiscus concinnus*.

From the adjoining series of quotations from the weekly reports, it is seen that the temperature of the sea was at its lowest (40° F.) early in February, and from that date the temperature rose gradually till it reached its highest point (61° F.) early in August, and then commenced to fall. The surface Algæ began to appear about the middle of May, when the temperature was 50° F., and continued to be present in great abundance for about six weeks, till near the end of June, and in less amount up to the 20th August, when they disappeared. After June, Medusæ, Ctenophora, Copepoda and other surface organisms were present in great abundance.

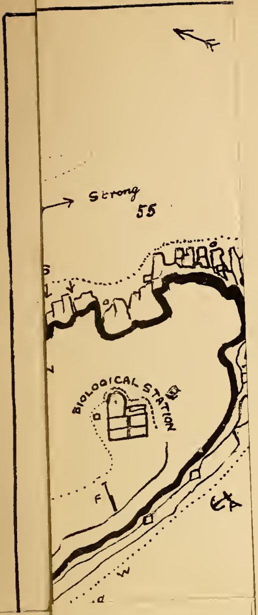
When these minute Algæ are present in quantity it is almost useless to tow-net, as the comparatively few other organisms present in the water become so entangled with the masses of Diatoms that it is almost impossible to separate them.

* "Fauna of Liverpool Bay," vol. i., p. 315, 1886.

† Ann. and Mag. Nat. Hist., Aug. 1887, p. 97.

‡ Journ. Mar. Biol. Assoc., vol. i., No. 2, Oct. 1889, p. 114.

DATE.		TEMP. OF SEA.	TEMP. OF AIR. *max.*	*min.*	CONDITION OF SEA.
1889.					
Jan.	1	45° F.	43°	33°	Water clear.
—	7	45.5°	50°	45°	
—	13	42°	42°	34°	
—	25	41.5°	44°	39°	*Sagitta* so abundant in all the surface tow-nettings both day and night, but especially the latter, as to obscure all else.
Feb.	7	41°	35°	28°	
—	11	40°	34°	27°	
—	17	42.5°	52°	44°	
—	27	41°	39°	33°	
Mar.	3	41°	33°	29°	Water becoming dirty (*Coscinodiscus concinnus*).
—	10	42.5°	47°	35°	*Sagitta* and *Calanus finmarchicus* abundant.
—	17	43°	51°	39°	Water very dirty. No use tow-netting.
Apr.	1	45°	50°	37°	Same condition continued for some time.
—	10	44°	42°	36°	Water clearing a little.
—	25	45.5°	54°	35°	Water still too dirty for tow-netting.
May	6	48°	64°	48°	Water clear again. Many larval Crustacea.
—	17	50°	64°	45°	Brown gelatinous matter appearing.
—	26	52°	60°	49°	Gelatinous matter in abundance.
June	13	54°	60°	49°	Gelatinous matter very thick.
—	21	56.5°	68°	56°	Water still full of gelatinous matter.
—	24	57.5°	64°	55°	First appearance of vivid phosphorescence at night.
—	26	58°	65°	58°	Medusæ in abundance.
July	3	59°	62°	44°	Small Medusæ in abundance.
—	23	59.5°	63°	50°	Medusæ still abundant.
Aug.	4	61°	64°	50°	Still some *Coscinodiscus concinnus*.
—	12	60.5°	60°	49°	Water very turbid.
—	28	60°	61°	49°	Water clear. Good tow-netting.
Sept.	4	58°	62°	45°	Ctenophora (*Pleurobrachia*) in great numbers.
—	17	57°	60°	50°	Ctenophora and *Sagitta* very numerous.
—	27	55°	56°	47°	Water very dirty. Tow-netting impracticable.
Oct.	4	52°	57°	44°	Tow-net choked with Ctenophora.
—	16	50°	55°		Ctenophora still numerous; also *Sagitta* and larval Decapods. Shoals of Herring round the island.
—	24	49°	49°		Water very dirty.


Strong
55
BIOLOGICAL STATION
F
W


PUFFIN ISLAND
AT LOW WATER SPRING TIDES.
By A. R.
Springs 26 feet, Neeps 16 feet rise.
INDEX :—
A....Ancharage.
B....Boulders.
E....Excavations.
F....Flagstaff.
G....Gardens.
H....High Level.
L....Landing Place.
M....Moorings.
N... Natural Shafts.
P....Path along Island.
T....St. Seirial's Tower.
S....Summit.
W....Wrecks.
Z....Tide marks for Towing.
Soundings in Feet.
Scale 10 Inches = 1 Mile.
OYSTER GROUND
FLOOD TIDE Strong
CAVES
E. Spit
No current at Ebb Tide
FLOOD
Ebb Tide
Cormorant Cliff
PUFFIN ISLAND
BIOLOGICAL STATION
THE COVER
Blue Clay
BAR
Dutchman Buoy
TURBOT HOLE
OYSTER GROUND.
Harpacticidae Pools.
Creek 1.
Creek 2.
BOTTLE ROCK
EBB
FLOOD
WEST SPIT
BEACON
THE RACE
SOUTH CHANNEL
Ebb Tide Strong
First 3 hours Flood Tide
Last hour Flood
Dries 2 ft.
Dries 1 ft.
Dries 6 ft.
Dries 9 ft.
IRISHMAN SPIT
Dries 9 ft. L.W. springs.
Dries 7 ft.
Whirlpools at flood tide.
MIDLAKE SWASH

The Puffins (*Fratercula arctica*) returned to the island this year on the 10th of April, a week earlier than in 1888, and left on the 19th of August. Their number remains about the same.

Zoning of the Shore.

About the middle of February, Mr. Thompson, Mr. Harvey Gibson and I visited the station for a few days, and we found that, notwithstanding the low temperature, work could be carried on both on the shore and in the laboratory. Mr. Thompson collected Copepoda, Amphipoda (including *Pleustes glaber*, new to Britain) and Isopoda; Mr. Gibson occupied himself with the Algæ, and I commenced detailed observations upon the zones of life on the shore (a subject which was referred to in the first of these reports), and arranged with the curator for the measurement of the exact distances of certain species of animals and plants vertically from high and low-water, and for the placing of permanent marks upon the shore at each end of the island so as to facilitate the taking of future observations and measurements.*

The "zoning of the shore" is no new subject, but it is one which is full of interest and may be susceptible of some new developments. From the earliest times marine biologists have noticed that the depth has a great effect

* These marks which have now been made upon the rocks are:—at the north end, near the laboratory, the average high-water mark (18 ft. tide) is shown by a red paint line labelled A.T., and low-water mark of the lowest springs (21 ft.) is shown by a blue line labelled L.S.; and at the south end, near the beach, high-water mark of the highest springs (21 ft.) is shown by a red line labelled 21, ditto of ordinary springs (19 ft.) by red line labelled 19, ditto of average tides (18 ft.) by red line labelled A.T., and ditto of smallest neaps (10 ft. 9 in.) by blue line labelled 10.9 on rock at both sides of beach. The accompanying new Chart of the Island and neighbourhood has been carefully prepared by Mr. Rutherford, the curator.

upon the fauna and flora of a region; and Professor Edward Forbes, in his posthumous work on the "Natural History of the European Seas," pointed out that the sea bottom explored by the naturalist might be conveniently divided into four great zones, each inhabited by particular sets of animals. These are: (1) the *Littoral zone*, or the area between high and low-water marks. The animals and plants are here, of course, under very peculiar conditions, being for a part of their lives submerged in the sea, while for another part they are exposed to the air, to the sunlight, to extremes of heat and cold, to the washing of rain, or it may be to the pelting of snow. Next comes (2) the *Laminarian zone*, which extends from low-water mark downwards to a depth of ten or fifteen fathoms. This is pre-eminently the region of sea-weeds and of abundant animal life. Here, amongst the great tangled masses of the shiny brown *Laminaria* or oarweed, we find a profusion of nearly all forms of marine life, and here occur many of those instances of protective colouring and mimicry which prove such interesting problems to the evolutionist. This is the region the upper edge of which is just exposed at extreme low water of spring tides, and at such times it yields a rich harvest to the collector. Following the Laminarian zone comes (3) the *Coralline zone*, or region of zoophytes, formerly known as "corallines." This zone extends down, on an average, to a depth of thirty fathoms or so; and it is the region in which most of the scientific dredging is carried on around our coasts. It contains very few sea-weeds, but a large and varied assemblage of animals. Lastly comes (4) the zone of *Deep Sea Corals*, whose lower limit Forbes did not fix. To these regions must now be added the *Abyssal zone*, made known by the dredgings of the "Porcupine," "Challenger," and other scientific expeditions.

Long before the time of Forbes, however, the two distinguished French naturalists Audouin and Milne-Edwards,* from their enthusiastic work as young men, among the rocks and islets of the Chausey Archipelago, and at other points along the coast of Normandy and Brittany, were able to distinguish five belts of life upon the shore:—(1) that of *Balani* (barnacles), only found on rocky coasts; (2) the zone of Fucoids, having limpets (*Patella*), whelks (*Purpura*, *Nassa*) and the common sea-anemone (*Actinia*) on rocks, sand-worms (*Arenicola*, *Terebella*) and sand-hoppers (*Talitrus*, *Orchestia*) on sandy shores, and certain other worms (*Nephthys*, *Sipunculus*) in mud; (3) the zone of "Corallines," only exposed at low tide, having mussels (*Mytilus*), simple and compound ascidians, crabs (*Porcellana*), *Doris*, worms (*Serpula*, *Polynoë*) and sponges in rocky places, the molluscs *Venus* and *Solen* in sand, and the small *Rissoa* and *Cerithium* in mud; (4) the zone of *Laminaria*, having starfish, sea-anemones and the beautiful limpet *Helcion pellucidum* on rocks, and certain crustaceans on sandy ground; and (5) the lowest zone in which are found oysters (*Ostrea*), the sea-mouse (*Aphrodite*), the swimming crabs (*Portunus*) and the larger starfishes.

The well-known Scandinavian zoologists M. Sars† (in 1835) and Sven Lovén (more recently) directed their attention to the distribution of life around the Norwegian shores, and marked out four belts lying between high water mark and the Laminarian zone, viz:—(1) "regio Balanorum," (2) "regio Patellarum," with *Fucus vesiculosus* and *F. nodosus* in its upper part, and *F. serratus* and

* See Ann. des Sc. Nat., 1re sér., t. xxi., p. 326, 1830; and Recherches pour Servir à l'Histoire Naturelle du Littoral de la France, 1832.

† Beskrivelser og Jagttagelser o. nogle mærk. eller. nye i Havet v. d. Bergenske Kyst lev. Dyr., Bergen, 1835.

F. siliquosus in its lower part, along with many shell fish; (3) "regio Corallinarum," with *Corallina officinalis*, many ascidians, sea-anemones, molluscs, worms and sponges; and (4) "regio Laminariarum," with nudibranchs, star-fishes, ascidians, *Helcion*, *Caprella*, *Nymphon* and *Echini*. The close correspondence between this classification and that of the French observers is very remarkable.

Ten years later A. S. Örsted, in an important essay,* showed that in the Strait of Öresund, near Copenhagen, three zones could be distinguished, both by the characteristic plants and the animals. To these he gave the names:—(1) "Regio Chlorospermearum," the belt of green sea weeds, extending from high water mark down to a depth of two to five fathoms, and corresponding to the "Regio Trochoideorum" amongst animals. The upper part of this zone is the subregion of the Oscillatorias, and the lower part the subregion of the Ulvas and Confervas. (2) is "Regio Melanospermearum," the belt of olive-brown sea-weeds, extending down to depths of seven or eight fathoms, and corresponding to the "Regio Gymnobranchiorum" amongst animals. Here also there are two subregions, an upper of Fucoids and *Zostera*, and a lower of *Laminaria*. (3) is "Regio Rhodospermearum," the belt of purple-red sea-weeds, extending from eight to twenty fathoms, and corresponding to the "Regio Buccinoideorum" amongst animals. As Vaillant has since pointed out, the somewhat abnormal conditions of marine life in the landlocked Strait of Öresund may account for the want of exact correspondence between these zones and those established on the more exposed coasts of France and Norway, but Örsted's first region evidently corresponds to the three upper zones of the French observers.

* De Regionibus Marinis. Havniæ, 1844.

Edward Forbes* himself, from his own work and a consideration of the observations of others, came to the conclusion that the subzones of his littoral zone (see above) are very well marked on the English coast, and can be distinguished by their characteristic plants and animals, as follows:—First two regions above half-tide mark (1) with *Fucus canaliculatus*, and the molluscs *Littorina rudis* and *L. neritoides*, and (2) with *Lichina*, *Patella*, *Balanus*, *Mytilus edulis* and incrusting nullipores; then a third and very prolific belt at half-tide (3) with *Chylocladia articulata* and *Fucus nodosus*, the molluscs *Purpura*, *Littorina littorea*, *Trochus umbilicatus*, and the common sea-anemone; then a fourth above low-water mark (4) with *Fucus serratus* and the molluscs *Littorina obtusata* and *Trochus cinerarius*, and finally, just at low-water mark a series of four very narrow bands most readily distinguished by their sea-weeds, (5) that of *Laurencia pinnatifida*, (6) *Conferva rupestris*, (7) *Chondrus crispus*, and (8) *Himanthalia lorea;* this last being the most constant, and being followed by the upper edge of the Laminarian zone, containing *Laminaria* on rocky coasts and *Zostera* on sandy.

Professor H. de Lacaze-Duthiers has defined on the shore at Roscoff, in Brittany, three zones, viz., (1) that of *Fucus*, (2) that of *Himanthalia*, and (3) that of *Sargassum*; and Professor Giard† has shown that special series of Compound Ascidians inhabit these definite belts.

About the same time Dr. Léon Vaillant‡ occupied himself with this subject in the same region, on the

* "The Natural History of the European Seas," edited by Godwin-Austen. London, 1859, p. 93.

† Archives de Zoologie expér. et génér., t. i., 1872.

‡ Observ. faites à St. Malo s. l. zones litt. supér., Bull. Soc. Philomat., Paris, nouv. sér., t. vii., p. 144, 1870; and Remar. s. l. zones litt., Soc. de Biologie Paris, 1872.

Brittany coast, and made some very interesting observations and experiments at St. Malo with the acorn-shell, *Balanus balanoides*, which is so commonly found at the extreme upper edge of the littoral zone on rocky coasts. Vaillant found that this marine animal, although it can only expand and obtain food when covered with water, is able to live so far above ordinary high-water mark as to remain dry for days at a time, amounting on an average to eighteen or nineteen-twentieths of its life; and he determined by experiment that it can live out of water for at least forty-four days at a time.

These observations are particularly interesting to me, as, before hearing in Paris last summer of Vaillant's work, I commenced some almost exactly similar observations at Hilbre Island, in 1885* and at Puffin Island in 1887, from which I made out that the Polyzoon *Flustrella hispida*, which is found within a yard of ordinary high-water mark, must be exposed to the air during about five-sixths of its existence, and can only feed during the remaining one-sixth at and about the time of high tide. Probably respiration can be carried on to a certain extent both in the case of this animal and of Vaillant's *Balani* by a little air being let in periodically to oxygenate the small quantity of sea-water shut in with the body of the animal.

Experiments on Harpacticidæ.

One of the first things one notices on examining the zones of life upon the shore at Puffin Island is that there are certain marine animals *above* high-water mark. There are some pools in the rocks which are only reached at high spring tides, or perhaps only by the spray from the waves during storms. These are overgrown with a common

* See Liverpool *Daily Post*, 15th June, 1885.

grass-green seaweed, *Enteromorpha intestinalis*, and on this we find enormous quantities of Copepoda belonging to the genus *Harpacticus*. The condition of some of the pools suggested to me that these animals would probably be able to stand considerable variations in the salinity of the water, as in wet weather they are flooded with rain while in dry summers the pools become almost or completely dried up.

So, taking some sample tubes of salt water with *Enteromorpha* and *Harpacticus fulvus* from the pool, I added to one a third of its volume of fresh water, and continued every morning to add a little fresh water, until at the end of twelve days there were nineteen parts of fresh water to one part of the original sea-water and the fluid was no longer salt to the taste. The *Enteromorpha* appeared healthy, and the Copepoda had increased greatly in numbers and were very active. The young ones hatched in the nearly fresh water were all colourless, but the adults had not lost their original bright red tint.

A second sample tube of *Harpacticus*, *Enteromorpha* and sea-water from the pool was emptied into a shallow glass dish and allowed to evaporate slowly. The Copepoda in this case did not increase in numbers, but they did not die until the dish was almost dry and the salt had crystallised out round the edges. After evaporation had been going on for a few days, I noticed that the Copepoda had retreated into the interior of the *Enteromorpha* filaments, where their bright red bodies were distinctly visible on the green ground, and I think that under natural conditions they might in this way escape death when their pool became dried up, as the desiccation would not be so thorough in the damp atmosphere of the sea-shore as in the warm dry air of my laboratory. Mr. W. J. Halls is going to take this matter up and carry out some further experiments with various species, and I have no doubt his results will be laid before us on some future occasion.

Experiments on Molluscs.

Scattered over the rocks at Puffin Island, above high-water mark, and above any of the sea-weeds, in the region of the little incrusting *Lichina pygmæa*, the region which Vaillant has called the subterrestrial or zero zone, we find numerous specimens of the small periwinkle *Littorina rudis*, and it is difficult to see how this mollusc manages to live, and why it has migrated so far up the shore. It feeds upon the lichen, and is very sluggish in its habits, often remaining for days—perhaps months—without moving from the one spot. Like its relations further down the shore, it is a branchiferous mollusc fitted for breathing in water, and yet we find it living and apparently flourishing in the air: possibly it may be in process by becoming adapted to a terrestrial mode of life. We know that some of these molluscs can shut themselves up in their shells so tightly as not to allow any water to pass in or out. Gosse has told how *Purpura lapillus* is able in this way to withstand the action of fresh water for eighteen hours. This may help us to understand how it is that some marine molluscs upon the rocks are not injured by drenching showers of rain, but it will scarcely solve the difficulty in regard to the specimens of *Littorina* which stick to the dry rock for many days, unless they have become adapted to breath in air, and some experiments which I have made render it probable that this modification has taken place.

I collected some specimens from the rocks above high-water mark, and after keeping them perfectly dry in a cardboard box in the laboratory for six days, during which time they showed no signs of life, I put ten of them into a glass jar of *fresh* water. In this they remained day after day with the operculum or lid which closes the mouth of the shell tightly shut. At the end of the second day, I took one of the specimens out of the water, and on opening the shell found that the animal was alive and active inside. On the fourth day two specimens died, on the sixth day four more, and by the end of the eighth day all of them were dead. Whether this death was due merely to the prolonged immersion in the fresh water, or may have been caused by the water becoming slightly impure, was uncertain, so the experiment has been repeated several times since (see below, jar B).

It is easy to tell whether the *Littorinas* are alive or dead, as, so long as a specimen is alive, it remains tightly shut up in its shell, while whenever it dies the operculum opens and a part of the "foot" of the animal protrudes in the form of a white mass, which rapidly begins to decompose.

I next collected from the rocks a fresh set of specimens, which were placed as follows:—

(A) Ten specimens in a jar of clear sea-water, under muslin (see below, fig. 3).

(B) Ten specimens in a jar of fresh water.

(C) Ten specimens in an empty dry jar (*i.e.* in air).

(D) Twenty specimens in a slate and glass aquarium, half full of sea-water and open at the top.

The jar A (see fig. 3) was so arranged as to have a piece of coarse muslin (*m*) spread over a hoop just below the surface of the sea-water, the object being to allow the air to have free access while preventing the molluscs from coming to the surface of the water.

These four sets of specimens were examined every twelve hours for three days, and their positions and apparent conditions carefully noted. The experiments were repeated several times, the general results being that:—

In the A jar, at the end of twelve hours all the specimens had crept up and were sticking to the under surface of the muslin; at the end of thirty-six hours, they had all fallen from the muslin, and were lying in various positions at the bottom of the jar; while at the end of the third day one or two were dead or dying, and most of the others seemed to be unwell. As the water in this jar had now gone bad, this experiment was not continued any further. Whether the sickly condition of the specimens in this jar was due merely to being kept immersed in sea-water for three days, or was caused by the water having become impure through the accidental (*i.e.* from some other, unknown, cause) death of one of the molluscs, it is impossible to say from a few experiments; but, at least, there is no doubt that the effect of putting closed up specimens of *Littorina rudis* into clean sea-water, out of which they cannot escape, is that they at once expand, become active, crawl as near as they can get to the surface of the water, and after remaining there for a time relax their hold and drop to the bottom.

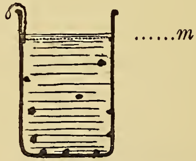


Fig. 3.—Experimental Jar containing *Littorina* kept in the water.

In B (fresh water), all the specimens remained during the three days lying at the bottom of the jar in a tightly closed up condition, but were apparently perfectly healthy at the end of that time. The jar was kept under observation for some time longer; the molluscs only began to die on the thirteenth day—a marked contrast to jar A. Consequently these "marine" molluscs can live longer in fresh water than in sea-water.

In C some of the specimens remained, in the contracted state, where they were put; while others crawled slowly about on the sides of the jar, a piece of glass over the top prevented their escape. None died: apparently, then, they can live best in the air.

Of the twenty specimens in the aquarium (D) seven had crawled out of the water in fifteen minutes; at the end of twelve hours fifteen had crept up the slate sides out of the water, and at the end of twenty-four hours nineteen had emerged from the water, and had travelled to distances of from one to four feet from the aquarium over the stone floor and painted plaster walls of the laboratory. I marked pencil rings round the five which had crawled farthest at the end of the second day, and found they went no farther after that during the two months they were under observation.

This experiment has been repeated several times with the same general result. All the specimens of *Littorina rudis* put in a contracted state into an open aquarium become active, and in the course of a day or two find their way out of the water, and after crawling for a little distance come to rest and remain there indefinitely. I have not noticed any specimens crawling downwards again into the water, even after being for days in the air.

Next, I made some observations on the specimens at the shore under their natural conditions. The rocks at Puffin Island are reefs and masses of carboniferous limestone, broken up by the waves and worn into crevices and crannies of all sizes and shapes. The *Littorinas* above high-water mark on these rocks are, I find, almost invariably in the hollows, either in rows along the lines of crevices, or singly at the bottom of the little rounded holes. They are never seen to move, they are attached to the dry rock, and with the exception of the dark coloured lichen *Lichina pygmæa* growing in patches, they have no visible means of subsistence.

It has been suggested that possibly they descend to the seaweed-covered rocks during the night and feed there; so to settle the matter as far as possible, I chose six fairly representative individuals, and without in the least disturbing them, I marked the shell and the hollow in which it was lying in such a way that it would be easy to detect any movement on the part of the mollusc. The first three were marked respectively with one, two, and three dots of red oil-paint on the shell, and one, two, and three rings round their hollows; while the remaining three

Fig 4.—Marked *Littorina* on the Rocks.

were similarly marked with blue paint (fig. 4). These marked molluscs were examined by myself at intervals of from six to nine hours for three days and nights (24th to 26th May), and during that time none of them changed their positions. After that they were watched for me by Mr. Rutherford until I returned to Puffin Island on the 7th June, when I found them unchanged. A second set of six molluscs, on the rocks at the north-east end, were marked with rings of paint as before by Mr. Rutherford, on 21st June, and were inspected every day, and remained in the same position until they were washed away on the

13th July by the spray from a heavy sea, caused by an easterly gale along with an unusually high spring tide. A new set were then marked (July 13th) higher up the rocks and remained unchanged in position till I saw them on my next visit on the 27th July, and Mr. Rutherford reported to me that they were still in the same spots, inside their little rings of paint, on the 13th August, when they had been exactly a month under observation.

Below the subterrestrial zone at Puffin Island we find the bands of life on the shore correspond very well with those recognised by Audouin and Milne-Edwards on the French coast, and by Edward Forbes in other parts of the British seas. We have (1) the region of *Balani* forming a well-marked line along the cliffs, (2) the area occupied by Limpets and *Littorina obtusata* on rocks covered with *Fucus nodosus*, *F. serratus*, and *F. vesiculosus*. In pools on this part of the shore is found *Corallina officinalis*. A little lower is the common sea-anemone (*Actinia mesembryanthemum*) in abundance, and under stones the annelids *Serpula* and *Spirorbis* and the Amphipod *Gammarus locusta*. At this point we have reached about six feet vertically below the highest Algæ on the rocks, and the first Hydroid Zoophytes are now found, *Diphasia pumila* on *Fucus* and *Laomedea* on the sides of stones, also *Membranipora pilosa* and *Chthamalus*. Then follow *Purpura*, *Anomia*, *Mytilus*, *Mucronella coccinea*, and various Zoophytes; then *Cancer pagurus* (small), *Alcyonidium gelatinosum*, and *Amphiura squamata*. We now reach the ten feet line vertically down from the top of the Algæ, and meet with *Halichondria panicea*, and *Porcellana platycheles* which extends from this point down to the Laminarian zone. Next is a very prolific zone, extending to low-water, in which occur *Alcyonium digitatum*, *Tealia crassicornis*, *Cribrella sanguinolenta*, *Asterias rubens*, *Serpula vermicularis*, *Sabellaria* *alveolata, Littorina littorea, Doris pilosa, Doris proxima, Chiton cinereus,* and numerous very fine specimens of *Bugula turbinata.*

During a considerable part of April, Mr. Harvey Gibson, Dr. Hanitsch and Mr. F. Villy worked at the station. Mr. Gibson confined his attention to the Rhodophyceæ, and he informs me that since his last report, published in the "Fauna," vol. ii., he has found and identified seventeen species of Algæ, mainly parasitic forms, not previously known in the district. Dr. Hanitsch has continued his researches on the Sponges during the year, and reports six species additional to those recorded in the "Fauna." Of these three are new to science and will be figured and described in detail under the names, *Axinella mammillata,* n. sp., *Leucaltis impressa,* n. sp., and *Halisarca rubra,* n. sp., in the next report on Sponges by Dr. Hanitsch. The last species was obtained by dredging in deep water during the "Spindrift" expedition of July 20th, while the two first were collected on the rocks at Puffin Island in April.

"Hyæna" Expedition.

The Salvage Association have again this year afforded us the opportunity of making some investigations which could certainly not have been carried on without the use of the s.s. "Hyæna." The old gunboat left the Mersey on Thursday morning, the 18th of April, on her fifth scientific cruise, and was absent five days. The proposed course was to cross to Port Erin, at the south end of the Isle of Man, and then dredge southwards to Holyhead, through the deepest water to be found in this district; then to work along the coast of Anglesey to Puffin Island, and from that back to Liverpool. Besides the ordinary dredging and tow-netting operations, it was hoped that two interesting new methods of collecting would be tried on this cruise. First, the submarine electric light, which gave such good results in the "Hyæna" expedition of the previous summer, was to be used as an attraction in the nets let down to the bottom at considerably greater depths than was the case in last year's experiments at Ramsey and Port Erin; and second, Mr. W. E. Hoyle's new tow-net (recently exhibited and described before the Biological Society of Liverpool*), which can be opened and closed at any required depth, so as to ensure that the contents of the net were captured in a particular stratum of water, was to be taken, with the view of trying whether it could be worked successfully.

It has often been felt by naturalists when they brought up free-swimming animals (such as fishes, medusæ, or crustacea) from considerable depths that it was uncertain when and where these animals entered the net. This was the case with many of the animals collected during the "Challenger" expedition. They were obtained in a dredge net, which had been down to a depth of one, two, or say three thousand fathoms, but for all we know they may have been caught on the way down, or on the way up, and may not be found at the bottom at all. Consequently, many attempts have been made to construct a net which can be sent down closed to a particular depth, and then be opened and towed open for some distance, and then be closed again before being hauled up.

Two of these are—(1) the Turbyne tow-net, used at the Granton Marine Station, where there are two ropes, one of which, used for letting down and hauling up the net, forms a slip noose constricting the mouth of the bag; and (2) the very elaborate piece of apparatus invented by the Prince of Monaco, and shown lately at the Paris

* See Proceedings, vol. iii., p. 100.

Exhibition, where the square mouth of the net is closed when required by a blind unrolled by the action of a descending weight.

Mr. Hoyle's net has been ingeniously devised to perform these same actions by means of a complex mechanism and two leaden "messengers," which are sent down the rope from the boat, the first to open the mouth of the net, and the second to close it. On account of the unfavourable weather, we were not able to give this net a fair trial on the "Hyæna" cruise; but later on, during the "Spindrift" expedition, it worked very satisfactorily.

The first day (April 18th) was spent in crossing to Port Erin, and after that the weather, although fine on land, became very unfavourable for marine work, and the programme had to be considerably altered. On Friday morning we steamed S.W. towards the deep water, but a strong wind was blowing, and after a haul of the dredge in twenty-seven fathoms, about five miles out, some bottom and surface tow-netting, a sounding in fifty fathoms, and then a further run to about nine miles from land, it was found that the heavy rolling of the vessel (even after the surface agitation had been considerably quieted down by the use of oil-bags hung over the windward bow) rendered dredging operations impossible out in the open sea; so the "Hyæna" was put about and returned to Port Erin, where tow-netting and other work was carried on in the bay.

The following day the wind was still stronger, so it was then decided to give up the Anglesey part of the cruise, and devote most of the remaining days to shore and shallow water work around the southern end of the Isle of Man. Accordingly, the rocks at Port Erin, Port St. Mary, Poyllvaaish Bay, and Fleshwick Bay were explored on the third day, and many specimens collected. On the north side of Fleshwick Bay there are some exquisite rock-pools lined with encrusting Nullipores and other seaweeds, and containing Sponges, Sea-anemones, Zoophytes, Polyzoa, Worms, Nudibranchs, and other animals. The rich green alga *Codium tormentosum* was obtained in these pools, but, although carefully searched for, no specimens of *Elysia viridis* were found upon it.

As the sea was still very rough, the early part of the fourth day was spent on board the "Hyæna," at anchor in Port Erin Bay. Tow-nets were let down, both on the surface and weighted so as to reach the bottom, and a small dredge with a long canvas net was taken out in a boat and used for obtaining samples of mud and sand to examine for small animals, such as Foraminifera, Copepoda and Ostracoda. The strong wind blowing was utilised by Captain Young, the representative of the Salvage Association, who suggested floating tow-nets across the bay with lifebuoys, and devised a sailing apparatus, consisting of an old lifebuoy rigged up with a mast and sail, and having a tow-net suspended from it, which was let out, carrying a long line, to leeward, and was then hauled in, the net keeping distended and working well during both the outward and the return journeys. Another surface net was even rigged up attached to a large kite, but this did not work satisfactorily. By these various means a large amount of material was collected and preserved for future examination. Mr. I. C. Thompson and Mr. W. S. McMillan, who are engaged in working out the Copepoda and Ostracoda of Liverpool Bay, have lately been getting some interesting species in mud and other deposits from Puffin Island and elsewhere, and they predict that it is from such sources that the most important additions to our fauna will be made in the future. Consequently, Mr. McMillan has devised a small dredging tow-net which will bring up samples of the bottom deposits, and this was frequently in use during the cruise. A new species of Copepod, which was obtained in this manner from muddy sand dredged in Port Erin Bay at a depth of five fathoms, has been named *Jonesiella hyænæ*, in honour of the old gunboat.

In the afternoon the "Hyæna" made two runs from Port Erin southwards to the Calf, dredging homewards with the wind, and got two excellent hauls, which contained, amongst other things, the rare coral-like *Sarcodictyon*, the flat pentagonal starfish *Palmipes*, the remarkable parasitic sea-anemone *Adamsia*, which is always found in company with a particular hermit crab (*Pagurus prideauxii*), *Echinocyamus pusillus*, *Stichaster roseus*, *Porania pulvillus*, *Lyonsia norvegica*, *Ascidia venosa* (with *Leucothoe spinicarpa* in the branchial sac), a sponge (*Esperella floreum*) new to the district, and various rare crustacea and mollusca.

Electric Light Experiments.

After dark, on two consecutive nights, the electric light was used for a couple of hours in collecting bottom and surface free-swimming animals around the ship, in much the same way as during the previous summer's cruise.

The first application of this important method of collecting appears to have been made by the United States Fish Commission in 1884, on board the steamer "Albatross." On that occasion an arc lamp was merely suspended above the surface of the water, and it was found to attract Amphipods, Squids, and young fish to the surface. In the following year the same naturalists experimented further by lowering an Edison incandescent lamp into the water, with similar good results. The Fish Commission do not give any details in regard to the animals collected, nor any comparison between the contents of illuminated and ordinary tow-nets worked at the same time.

The next submarine electric light experiments were those carried out by the L.M.B.C. in May, 1888, on board the "Hyæna," as detailed in last year's Report.* Just a month later in that same summer (24th to 26th June, 1888) Prince Albert of Monaco† used on board his yacht "Hirondelle," a tow-net lit by a small Edison incandescent lamp (12 volts), supplied by a single Bunsen cell in which the nitric acid was replaced by chromic acid. The battery, which is let down into the sea along with the net, is hermetically sealed up in an iron case, while when the apparatus is used in great depths, the pressure is ingeniously equalised by a tube connecting the interior of the case with a strong indiarubber ball filled with air. This apparatus was tried in the neighbourhood of the Azores down to a depth of about twenty fathoms.

It may be useful to state here that the "Hyæna" is fitted up with the following electric light installation ‡:— A Gwynne vertical engine, of six nominal horse-power, running at 300-400 revolutions per minute, works a Phœnix compound-wound dynamo, with an effective output of 5,980 Watts (65 volts, 92 amperes) at 1,000 revolutions per minute. There are two Pilsen arc lamps of 3,000 nominal candle-power each, which can be used on deck or at mast head, or on the side of the ship; four Edison-Swan submarine incandescent lamps of 100 candle-power, and ten of sixteen candle-power each. The dynamo, being compounded, allows the arc and incandescent lamps to be

* And in *Nature*, vol. xxxiii., June 7, 1888.

† Comptes-rendus, t. cvii., July 9, 1888.

‡ I am indebted to Captain F. Young of the Liverpool Salvage Association for this information in regard to the plant on board the "Hyæna."

run together with perfect ease by the use of a resistance of about 0·5 of an ohm in the arc-light circuit. The submarine lamps are fitted in strong circular annealed glass protectors, and can be lowered to any required depth in the water by means of a special waterproof flexible cable made of 260 strands of fine copper wire, covered with thick gutta percha and hemp. The arc lamps require from twenty-five to thirty amperes, and the submarine lamps 4·5 amperes, so that there is ample power when the whole installation is running.

This time the two large electric lamps, 3,000 candle-power each, were hoisted up into such a position as to illuminate the deck, and cast a bright light on the water for some distance on each side of the ship. Three submarine incandescent lamps of 100 candle-power each were then fitted in the mouths of tow-nets, and were let down, two of them to the bottom, at a depth of five fathoms, and the third to a foot or so below the surface of the sea. Each of these nets was put out twice, so that we got four bottom hauls and two surface hauls with the electric light tow-nets. Another tow-net without any lamp was let over the side of the "Hyæna," and lay in the brightly illuminated surface water. All these nets were stationary, but were kept fairly distended by the tide. At the same time Mr. I. C. Thompson was rowed round and round the ship, dragging an ordinary tow-net in the bright area, and this one haul, in addition to many higher Crustacea, yielded *Gastrosaccus spinifer*, *Siriella brooki*, and some very interesting varieties of *Atylus swammerdamii*, which Mr. A. O. Walker is now working out, and twenty species of Copepoda, including such rare forms as *Pseudocalanus armatus*, *Ectinosoma atlanticum*, *Zaus spinatus*, *Laophonte lamellifera*, *Dactylopus tenuiremis*, *D. tisboides*, *Cyclopina gracilis*, *Bradya typica*, *Euterpe gracilis*, and quantities of *Peltidium* *depressum*. This last species is usually found attached to the surface of *Laminaria* and other Algæ at the bottom, and *Pseudocalanus armatus* has apparently only been found in British seas before at considerable depths in the Clyde estuary. Consequently their presence on the surface is remarkable, and was, no doubt, caused by the attraction of our powerful electric light.

All the nets were, on this occasion, used in water lighted up, the surface nets being in the 6,000 candle-power glare, while the bottom nets were further from this bright light, but had each their own smaller lamps. All gave, so far as we yet know, practically similar results, which are markedly different from both the bottom and the surface gatherings taken at the same place during the previous day. The electric light gatherings contain chiefly Schizopoda, Cumacea and Amphipoda, and the Cumacea, chiefly adult males of *Iphinoe trispinosa*, with their long slender red bodies and active movements, are the most marked feature; they are very abundant, and form a conspicuous characteristic in the gathering whenever it is transferred from a net into a glass jar. In none of the daylight tow-nettings, either bottom or surface, I think, was a single cumacean obtained, while every gathering on the two nights when we had the electric light going contained Cumacea in abundance. There can be little doubt that those captured in the surface nets had been attracted from the bottom by our brilliant deck lights, which had been shining for fully half an hour before the nets were put over.

On the fifth day the "Hyæna" started in the morning from Port Erin, and arrived at Liverpool soon after midnight. A little dredging and tow-netting was done on the way. One good haul was obtained from a stony and shelly bottom at about fifteen miles south-east of the

Chicken Rock (depth thirty fathoms), which yielded large numbers of polyzoa. These have been examined by Mr. Lomas, who tells me that they include *Cellaria fistulosa* (very abundant) and *C. sinuosa* (new to "Fauna"), *Cellepora dichotoma*, *Stomatopora major* and *S. johnstoni*, *Tubulipora lobulata* and *T. flabellaris*, and a number of common forms.

At this spot also, it being the deepest water on our homeward track, we let the electric lamp down to the bottom in a tow-net (see fig. on page 75) twice, and got gatherings, consisting mainly of Copepoda, Sagitta, Amphipoda, Zoëas, and other larval forms.

That free-swimming Crustaceans are attracted to a stationary net by the electric light may now, after our experiments of 1888 and on this last cruise, be considered established beyond doubt; and that the illuminated tow-net can be used in at least moderately deep water was evident to all who saw the success with which the net was worked on board the "Hyæna" in thirty fathoms.

The submarine electric light is, therefore, an important addition to the collecting methods of the marine biologist, and one which ought certainly to come into extensive use in the future. It is, of course, only very rarely that a vessel like the "Hyæna," so fitted up that the electric light can be turned on readily at any time to illuminate a series of nets, is placed at the use of the biologists, and to fit out a boat specially with an engine and dynamo and a set of lamps, would be a very expensive matter. I thought at one time that storage batteries might serve the biologist's purpose, but on making inquiries in Liverpool we found that for even a day's work a considerable number of batteries would have to be taken, and the expense would be too great. The plan of sending a primary battery down in the net, as in the case of the

Prince of Monaco's experiments, seems on the whole—if it gives a bright enough light and works satisfactorily—to be the simplest and most economical method, and the one which it would be best to adopt where no vessel already provided with an electric installation is available.

As to the practical application of this method to fisheries, although there can be no doubt that the electric light acts powerfully in attracting many free-swimming animals, and especially Crustacea, there is no very good evidence that it attracts marine fishes. More experiments are required before the matter can be considered as settled, but I am inclined at present to agree with the opinion which has been expressed by some of the American investigators, that the method is of more value to the scientific biologist than to the practical fisherman.

Additional Copepoda.

While collecting near low water mark on the south spit at Puffin Island, one evening in summer, I found attached to a colony of *Lepralia*, under a stone, a beautiful little discoid pink and white Copepod, which Mr. Thompson has since identified as *Artotrogus orbicularis*, Boeck, a species never previously found in British seas. Ninety-four species of Copepoda in all have now been recorded from our district, of these thirteen are new to Britain and four (*Lichomolgus sabellæ*, *Hersilioides puffini*, *Cymbasoma herdmani*, and *Jonesiella hyænæ*) new to science. Mr. Thompson tells me that since the publication of his last report ("Fauna," vol. ii., containing Reports ii. and iii. and Appendix), he has found the three following species (new to our lists) in addition to the *Artotrogus* mentioned above, all from the examination of mud and other deposits: *Amymone longimana*, *Delavalia palustris* and *Artotrogus* *magniceps*. Another notable point in regard to the Copepoda is that at Puffin Island on the night of May 17th, *Cyclopina littoralis*, one of the rarer species, and usually found singly, appeared in a shoal, and numerous specimens were captured.

"Spindrift" Expedition in June.

This year the Government Grant Committee of the Royal Society placed £50 at the disposal of the L.M.B.C. for the purpose of hiring vessels and men in carrying on the exploration of Liverpool Bay by dredging expeditions. The steam-tug "Spindrift" was accordingly chartered on two occasions from the Liverpool Tug Company for single day expeditions. Such exploring trips are very important, and every one of them adds considerably to our knowledge of the district. Unfortunately, however, they are so expensive that in the present state of our funds we cannot afford to have more than one or two in each season. If tug companies or owners of small steamers would lend us a vessel occasionally for a single day or a week-end, it would materially aid our work and advance the scientific knowledge of Liverpool Bay.

The first of these expeditions was on Saturday, the 8th June, which proved one of the finest days of the summer for work at sea. A number of members of the Committee and other naturalists went down to the Menai Straits on the previous day, and the "Spindrift" arrived off Puffin Island at five a.m. on 8th June, and, after taking some of the party on board from the Biological Station and others from Beaumaris, steamed to the "Turbot Hole," off the N.E. end of the island, and commenced the work of the day. We then proceeded along the north coast of Anglesey, round Point Lynas, as far as Porthwen Bay, and dredging was carried on with varying success until about nine p.m., when, after a final haul in the Turbot Hole, the biologists were again landed on Puffin Island. The following is a summary of the observations made on this expedition :—

(A) Turbot Hole, off Puffin Island, sixteen fathoms; two good hauls :—*Cucumaria planci*, *Thyonidium drummondi*, Zoophytes, and many other things.

(B) West of "Little Mouse," round Point Lynas, nineteen fathoms, gravel, shells and sand; one haul :—*Hydractinia*, Sponges, *Dentalium* and *Echinocyamus*.

(C) Off Porthwen Bay, seventeen fathoms; one haul:—*Pecten varius*, *Fissurella græca*, *Cypræa europea*, *Antedon*, *Sabellaria*, *Phascolosoma vulgare* (*Syrinx harveyi*), *Dentalium entale*, and Ascidians (*Ascidia plebeia*, *Styela grossularia*, and *Polycarpa pomaria*).

(D) Same, two miles off shore, twenty to twenty-two fathoms; two hauls :— *Garveia nutans*, *Antennularia ramosa*, *Antedon rosaceus*, *Fissurella græca*, *Murex erinaceus*, *Natica*, *Nucula* and *Cellepora*.

(E) Off Point Lynas; in first haul lost large dredge, then one haul with small dredge :—*Spatangus purpureus* in sand.

(F) Off Dulas Island, thirteen to fifteen fathoms, sand and shells :—*Solaster papposa*, Sponges and Ascidians.

(G) Same, further off land, twenty fathoms :—*Spatangus purpureus* in abundance.

(H) Off middle of Red Wharf Bay, twenty fathoms :—*Spatangus*.

(I) Turbot Hole, sixteen fathoms; one haul :—Same results as before.

These hauls yielded many interesting Crustacea to Mr. Walker. Some of the best of these were obtained by placing the sand and gravel brought up in the dredge in dishes of sea water, when many Amphipods swam out.

Galathea nexa, *Crangon nanus*, *Mysis inermis*, *Cuma edwardsii* (with ova), *Atylus uncinatus* (new to Britain), *Autonoe longipes*, *Lilljeborgia pallida*, *Podocerus ocius*, *Dryope irrorata*, and *Unciola planipes* were all added to our lists on this occasion.

Most of the material collected during this expedition, coming as it did too late for insertion in the detailed reports which make up vol. ii. of the "Fauna," has not yet been distributed to our workers. Miss L. R. Thornely, who has kindly undertaken to sort out the collection into groups and identify the Hydroida, tells me that we have now collected twenty-nine species of Zoophytes, from the immediate neighbourhood of Puffin Island, including a number of forms not previously known from that part of our district; and Mr. Halls, who is working in the zoological laboratory at the Zoophytes collected off the south end of the Isle of Man, reports that he has identified fourteen species, and is now examining a mass of new material.

For a couple of days after the "Spindrift" expedition of 8th June, most of the dredging party stayed on Puffin Island, and a great deal of investigation was carried on, there being twelve biologists at work, the largest number since the opening of the station. Mr. J. Vicars devoted the time entirely to collecting and identifying the land plants of the island, and added considerably to the list drawn up by Mr. Dutton (Chester) and Dr. C. H. Hurst (Manchester) in 1888;* Mr. Alf. Leicester collected land Mollusca, and succeeded in obtaining sixteen species, upon which he has submitted a short report to the Biological Society; while the rest of the party were at work either on the shore or in the laboratory. A large number of

* This list, still further augmented by Mr. Harvey Gibson and Professor McNab, is published as Appendix (A) of this report.

Polyzoa have been collected during the year at Puffin Island, and Mr. Lomas reports to me that these include *Valkeria uva*, *Cellepora armata* and *C. dichotoma*, and many other commoner forms.

"Spindrift" Expedition in July.

On Saturday, the 20th July, a most unfortunate day as far as weather was concerned, the "Spindrift" arrived at Holyhead, at five a.m., and took on board the party of biologists who had gone down by train from Liverpool the previous afternoon. The object on this occasion was to explore the deep water lying south of the Isle of Man, and which the bad weather at Easter had prevented us from reaching during the "Hyæna" expedition.

Fig. 5.—The L.M.B.C. District.

We got on the right ground this time, and had several hauls in from forty to sixty fathoms; but it rained hard and blew all day, and there was a heavy southerly swell, and finally the trawl and the chief dredge were rendered useless by dragging over the rough bottom, so the work had to be given up earlier in the afternoon than usual. Consequently I feel that this region between the Isle of Man and Holyhead has not yet been sufficiently investigated, and that it is very desirable that we should have at least another day's work there, in favourable weather, with a powerful tug such as the "Spindrift" or the "Gamecock."

Amongst the rarer species obtained from over fifty fathoms during this trip were: *Cynthia tessellata*, *Amphiura ballii*, *Palmipes membranaceus*, *Balanus porcatus*, and a new species of Sponge (*Halisarca rubra*, n. sp.), encrusting the shell of *Mytilus*, which will be described and figured by Dr. Hanitsch in a future report. Mr. Walker informs me that so far as the Crustacea are concerned this trip was disappointing, the only addition to the "Fauna" being *Hippolyte spinus*. *Euonyx chelata*, a rare Amphipod, once before taken at Puffin Island, was however found abundantly on *Echinus sphæra*.

Deep-sea Tow-net.

On this occasion Mr. Hoyle's deep-sea tow-net was used down to a depth of thirty fathoms. The closing apparatus worked without a hitch, save once, when a small piece of rope which was drifting in the water became twisted round the line and thus prevented the descent of the messengers. The possibility of such an occurrence had always been foreseen, but it is not sufficiently serious to militate against the use of the apparatus in shallow water. The operation does not take long, and if one haul should fail it is easy to make another. In the exploration of great depths, however, the case is different. The period occupied in letting out and hauling in the line, taken in conjunction with the time required for dragging the net, is then so great that it becomes imperative to remove every possible risk of losing an observation. Furthermore, the time occupied by the messengers themselves in descending the line is a not unimportant factor in the case.

The Committee* appointed by the British Association to investigate this matter were so much impressed by these considerations that it was resolved to attempt the construction of a piece of apparatus which should bring about the opening and closing of the net by means of an electric current, transmitted along wires passing down the interior of the line by which the net is drawn. This plan has so far succeeded that Mr. Hoyle has already constructed a provisional model. The lock (a piece of brass near the mouth of the net) contains an electro-magnet the armature of which actuates an escapement which the first time contact is made liberates the opening rod, and the second time the closing rod of the net. Such an arrangement is obviously instantaneous in its action, and not liable to interference from external causes. It is hoped that this electric tow-net will be ready for use soon, so that we may be able to experiment with it during next season's expeditions.

Higher Crustacea, &c.

During the summer a good deal of shore collecting and of dredging with a small canvas dredge has been carried on by Mr. A. O. Walker, in Colwyn Bay and off the Little Orme's Head, resulting in the addition of the following species :—*Mysis inermis* and *M. ornata*, *Lamprops fas-*

* Consisting of Prof. Schäfer, Prof. Herdman and Mr. Hoyle (Secretary). See Report of the Committee, read at the Newcastle-upon-Tyne meeting, 1889, from which some of the particulars given above are taken.

ciatus, *Danaia dubia*, *Atylus falcatus*, *Microprotopus maculatus* and *Corophium bonellii*. Mr. Walker also reports that in dredging on sand and mud in two and a half fathoms, at Colwyn Bay, in November, he came across a great number of females and one or two immature males of *Diastylis bradyi*, and a single adult male of *D. spinosa*, and he suggests that possibly the so-called immature males of *D. bradyi* may really be the females of *D. spinosa*. The pretty little Amphipod *Megaluropus agilis*, first described by Dr. Norman only last June, is now found to be not uncommon in Colwyn Bay. Mr. Walker informs me that the collections of Crustacea we have made this year exceed in bulk those of any previous year, and although they are not yet half worked out they have yielded a considerable number of novelties.

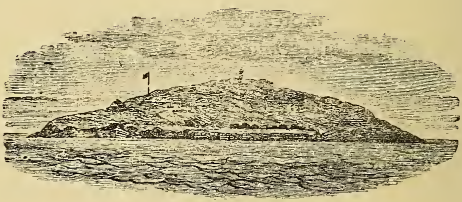
Towards the end of July, Mr. I. C. Thompson, the late Professor W. R. McNab, of Dublin, Mr. R. J. H. Gibson and I were at Puffin Island for a few days. Professor McNab and Mr. Gibson worked partly at the Algæ and partly at the land plants; while I occupied myself with further observations on the distribution of the animals over the littoral zone. At this time there were considerable numbers of two species of Pycnogonids on the under sides of stones. The one (*Nymphon* sp.) is of a straw-yellow colour, and is found adhering to Sertularian Zoophytes which are of the same tint; while the other species (*Phoxichilus spinosus*) is red and affects *Tubularia*, and a sea-weed (*Chylocladia articulata*) having also a dull red tint.

We have found the following Nudibranchs during the year at Puffin Island:—*Doris tuberculata*, *D. proxima*, *Goniodoris nodosa*, *Ancula cristata*, *Tritonia plebeia*, *Eolis viridis*, and the spawn of *Tergipes despecta*. No specimens of *Dendronotus arborescens* have yet been seen, so very probably the attempt described in last year's report to transplant this species from Hilbre Island to Puffin has failed. The nudibranchs at Puffin Island along with those at Hilbre have afforded material to Mr. Clubb and myself for a number of anatomical observations during the year, as well as for those theoretical conclusions in regard to the usefulness of the branched and highly-coloured processes from the body as protecting or warning marks, which I discussed in my Presidential Address to the Biological Society. This theory in regard to the function of these structures, and of the colouring of the nudibranchs generally, has been arrived at independently this summer by the investigators at three separate biological stations, viz.—Professor Giard's laboratory at Wimereux, our own at Puffin Island, and, a little later, at the Plymouth laboratory.

I am now carrying on some experiments at the museum tanks for the purpose of determining to what extent the different kinds of nudibranchs are eaten by various coast fishes, such as the blenny, sole, plaice, turbot, conger, wrasse, &c.; and whether the conspicuously coloured forms with stinging threads, such as *Eolis*, are refused, while the protectively coloured harmless forms, such as *Tritonia* and *Doto* are eaten when visible. The experiments are being carefully recorded, and the results will be discussed in a future report.

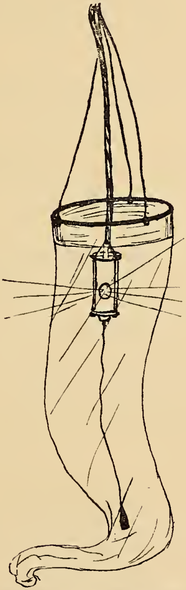
Towards the end of autumn the L.M.B. Committee decided to close the biological station for the winter. The considerable distance, the numerous winter engagements in town, and the uncertain weather, have rendered it impracticable for our workers, with a very few exceptions, to visit Puffin Island at this season, and as it was found that even when at the station comparatively little could be done on the shore, or out in the boat in the short, cold winter days, it seemed wise to economise time, money and energy by shutting up the laboratory from October till April. Consequently, the boats have been placed in safety in the Menai Straits, the apparatus and specimens have been brought up to University College, the curator has obtained a situation for the winter in Liverpool, and the station has been securely locked up. It is proposed to re-open the establishment at the beginning of either April or May, according to the weather and the wishes of our workers, and I have no doubt that next summer all the various lines of investigation now started will be followed up with a renewed enthusiasm which will more than make up for the loss of the winter observations.

A catalogue of the land plants which have been recorded, the usual list of subscribers to the L.M.B.C. funds and the Hon. Treasurer's balance sheet for the year are appended.



Applications to be allowed to work at the Biological Station, or for Specimens (living or preserved) for Museums, Laboratory Work, and Aquaria, should be addressed to Professor Herdman, University College, Liverpool.

Subscriptions and Donations should be sent to Mr. I. C. Thompson, F.L.S., 19, Waverley Road, Liverpool.



Tow-net with Electric Light.

[For the use of this cut I am indebted to the courtesy of the editor of "Life Lore."]

APPENDIX A.

FIRST LIST of PLANTS on PUFFIN ISLAND.

[I have compiled this list from the records in the station "Journal" commenced by Mr. F. V. Dutton (Chester), 24th July, 1888, continued by Dr. C. Herbert Hurst (Manchester), and added to by Mr. J. Vicars (Bootle), Mr. R. J. Harvey Gibson (Liverpool), and the late Professor McNab (Dublin). The nomcnclature and arrangement are those of Bentham and Hooker' Handbook.—W. A. H.]

DICOTYLEDONS.

I. THALAMIFLORÆ.

RANUNCULACEÆ.

Ranunculus repens, L., Creeping R.

CRUCIFERÆ.

Cochlearia officinalis, L., Scurvy-grass.

VIOLARIEÆ.

Viola canina, L., Dog violet.

CARYOPHYLLACEÆ.

Sagina procumbens (*apetala*), L., Pearlwort.
Cerastium sp.
Spergularia rubra (*salina*), Pers., Sandspurry.

GERANIACEÆ.

Geranium molle, L., Dove's-foot G.
Erodium maritimum, L'H., Sea E.

II. CALYCIFLORÆ.

LEGUMINOSÆ.

Trifolium repens, L., White clover.
Lotus corniculatus, L., Bird's-foot trefoil.

ROSACEÆ.

Prunus communis, Hud., Blackthorn.
Rubus fruticosus, L., Bramble.
Potentilla reptans, L., Cinquefoil.

CRASSULACEÆ.

Sedum acre, L., Biting sedum.

UMBELLIFERÆ.

Crithmum maritimum, L., Samphire.
Daucus carota, L., Carrot.
Conium maculatum, L., Hemlock.

ARALIACEÆ.

Hedera helix, L., Ivy.

III. MONOPETALÆ.

CAPRIFOLIACEÆ.

Sambucus nigra, L., Elder.

RUBIACEÆ.

Galium verum, L., Ladies' bedstraw.

DIPSACACEÆ.

Dipsacus sylvestris, L., Teasel.

COMPOSITÆ.

Bellis perennis, L., Daisy.
Inula sp.
Senecio jacobæa, L., Ragwort.
Arctium lappa, L., Burdock.
Carduus lanceolatus, L., Spear thistle.
Carduus arvensis, Curt., Creeping thistle.
Carduus pycnocephalus, L., Slender thistle.
Carlina vulgaris, L., Common carline.
Leontodon sp., Hawkbit.
Sonchus sp., Sow thistle.
Taraxacum dens-leonis, Desf., Dandelion.
Hieracium sp., Hawkweed.

PRIMULACEÆ.

Anagallis arvensis, L., Common pimpernel.

OLEACEÆ.

Ligustrum vulgare, L., Privet.

BORAGINEÆ.

Myosotis collina, Hoffm., Early Forget-me-not.
Myosotis arvensis, Hoffm., Field Forget-me-not.
Myosotis versicolor, Pers. (?)
Lycopsis arvensis, L., Bugloss.

SOLANACEÆ.

Hyocyamus niger, L., Henbane.

SCROPHULARINEÆ.

Verbascum thapsus, L., Great mullein.
Scrophularia nodosa, L., Figwort.
Veronica sp., Speedwell.
Veronica chamædrys, L., Germander speedwell

LABIATÆ.

Ballota nigra, L., Black horehound.
Calamintha sp.
Nepeta glechoma, Benth., Ground ivy.
Prunella vulgaris, L., Self-heal.
Teucrium scorodonia, L., Wood sage.

PLUMBAGINEÆ.

Armeria vulgaris, Willd., Common Thrift.

PLANTAGINEÆ.

Plantago media, L., Hoary Plantain.
Plantago lanceolata, L., Ribwort P.
Plantago coronopus, L., Buck's-horn P.
Plantago maritima, L., Sea P.

IV. MONOCHLAMYDÆ.

CHENOPODIACEÆ.

Chenopodium album, L., White Goosefoot.
Chenopodium rubrum, L., Red Goosefoot.
Beta maritima, L., Common Beet.

POLYGONACEÆ.

Rumex crispus, L., Curled Dock.
Rumex acetosa, L., Sorrel.
Rumex acetosella, L. Sheep sorrel.

URTICACEÆ.

Urtica dioica, L., Common Nettle.
Urtica urens, L., Small Nettle.
Parietaria officinalis, L., Pellitory.

MONOCOTYLEDONS.

AROIDEÆ.

Arum maculatum, L., Cuckoo-pint.

ORCHIDACEÆ.

Orchis maculata, L., Spotted Orchis.

IRIDEÆ.

Iris fœtidissima, L., Fetid Iris.

LILIACEÆ.

Scilla nutans, Sm., Bluebell squill.

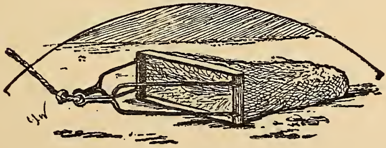
GRAMINEÆ.

Holcus lanatus, L., Common H.
Arrhenatherum avenaceum, Beauv., False-oat.
Festuca ovina, L., Sheep's fescue.
Poa (Sclerochloa) maritima, Huds., Sea poa.
Aira præcox, L., Early Aira.
Bromus arvensis (mollis), L.

CRYPTOGAMS.

FILICES.

Asplenium ruta-muraria, L., Wall-rue.
Asplenium marinum, L., Sea-spleenwort.
Aspidium filix-mas, Sw., Male Fern.



APPENDIX B.

SUBSCRIPTIONS and DONATIONS.

	Subscriptions.			Donations.		
	£	s.	d.	£	s.	d.
Banks, Prof. W. Mitchell, 28, Rodney-st.	2	2	0		—	
Bickersteth, Dr., 2, Rodney-street	2	2	0		—	
Booth, Alfred, 14, Castle-street		—		5	0	0
Brook, George, 19, Greenhill Gardens, Edinburgh	1	1	0		—	
Brown, Prof. J. Campbell, University College, Liverpool..........................	1	1	0		—	
Brown, J. Harvie, Dunipace House, Larbert, N.B.	0	10	0	1	0	0
Burton, Major, Fryars, Beaumaris	2	2	0		—	
Caine, Nath., 10, Orange-court, Castle-st.	1	1	0		—	
Caton, Dr., 31, Rodney-street		—		1	1	0
Chadwick, H. C., 2, Beech-road, Chorlton-cum-Hardy, Manchester..................	0	5	0		—	
Clemence, S., Chester	1	1	0		—	
Comber, Thomas, Leighton, Parkgate......	1	1	0		—	
Coventry, Joseph, 24, Linnet-lane	1	1	0		—	
Davidson, Dr., 2, Gambier-terrace	1	1	0		—	
Denny, Prof., Firth College, Sheffield......	1	0	0		—	
Derby, Earl of, Knowsley	5	0	0		—	
Drysdale, Dr., 36A, Rodney-street	1	1	0		—	
Fritsch, Dr. Anton, Prague		—		3	0	0
Gair, H. W., Smithdown-road, Wavertree	2	2	0		—	
Gamble, Col. David, Windlehurst, St. Helens	2	0	0		—	
Gaskell, Holbrook, J.P., Woolton Wood, Much Woolton	1	1	0		—	
Gaskell, E. H., North Hill, Highgate, London		—		3	3	0
Gibson, R. J. Harvey, 16, Sydenham-avenue	1	1	0		—	

	Subscriptions. £	s.	d.	Donations. £	s.	d.
Gifford, J., Whitehouse-terrace, Edinburgh	1	0	0		—	
Glynn, Dr., 62, Rodney-street	1	1	0		—	
Halhed, W. B., Sunnyside, Prince's Park.	1	1	0		—	
Halls, W. J., 35, Lord-street	1	1	0		—	
Henderson, W. G., Liverpool Union Bank	1	1	0		—	
Herdman, Prof., Univ. College, Liverpool.	2	2	0		—	
Higgin, Thos., Ethersall, Roby	1	1	0		—	
Holder, Thos., 1, Clarendon Buildings, Tithebarn-street	1	1	0		—	
Holland, Walter, Mossley Hill-road	2	2	0		—	
Holt, George, J.P., Sudley, Mossley Hill...	1	0	0	5	0	0
Hornby, T. D., The late, Olive Mount, Wavertree	1	1	0		—	
"Hyæna"—collected on board.......		—		3	8	6
Johnstone, Rev. Geo., M.A., 41, Bentley-rd.	0	5	0		—	
Jones, Chas. W., Field House, Wavertree	5	0	0		—	
Jones, J. Birdsall, 10, St. George's-crescent	1	1	0	1	1	0
Leicester, Alfred, 24, Aughton-rd., Birkdale	1	1	0		—	
Macfie, Robert, Airds..	1	0	0		—	
Marshall, Prof. A. Milnes, Owens College, Manchester	1	1	0		—	
McMillan, W. S., 17, Temple-street	2	2	0		—	
McMillan, R., 20, Aubrey-street	0	15	0		—	
Meade-King, R. R., 4, Oldhall-street	0	10	0		—	
Meade-King, H. W., Sandfield Park, West Derby	1	0	0		—	
Melly, George, 90, Chatham-street	1	0	0		—	
Melly, W. R., 90, Chatham-street	1	0	0		—	
Miall, Prof., Yorkshire College, Leeds......	1	1	0		—	
Muspratt, E. K., Seaforth Hall		—		5	0	
Nicol, W., St. Michael's Mount, St. Michael's	1	1	0		—	
Oelrichs, W., 3, Wexford-road, Oxton......	1	0	0		—	
Phillips, Prof. R. W., Univ. College, Bangor	1	1	0		—	
Poole, Sir James, Tower Buildings	2	2	0		—	

	Subscriptions. £	s.	d.	Donations. £	s.	d.
Rathbone, R. R., Beechwood House, Grassendale	2	2	0	—		
Rathbone, Theo., Backwood, Neston	2	2	0	—		
Rathbone, W., M.P., Greenbank, Allerton	2	2	0	—		
Roberts, Isaac, Kenessee, Maghull	1	0	0	—		
Samuelson, Edward, J.P., Trefriw, North Wales	1	0	0	—		
S.B.D., per Prof. Herdman	—			0	5	0
Scott, W. G., 26, Dingle-lane	1	1	0	—		
Shepheard, T., Kingsley Lodge, Chester	1	1	0	—		
Smart, Rev. E. H., Kirby-in-Cleveland, Northallerton (Half-year's Sub.)	0	10	6	—		
Swainson, Geo., North Drive, St. Anne's-on-the-Sea	1	1	0	—		
Tate, A. Norman, 9, Hackins-hey	2	2	0	—		
Thompson, Isaac C., Woodstock, Waverley-road	2	2	0	—		
Thornely, James, Baycliff, Woolton-hill	1	1	0	—		
Thornely, The Misses, Baycliff, Woolton	1	0	0	—		
Toll, J. M., 340, Walton Breck-road	1	1	0	—		
Vicars, John, 8, St. Alban's-square, Bootle	2	2	0	—		
Villy, F., 7, Barton-street, Moss Side, Manchester	—			1	0	0
Walker, Alfred O., Nant-y-glyn, Colwyn Bay	5	0	0	—		
Walker, Horace, South Lodge, Prince's Pk.	1	1	0	—		
Watson, A. T., Tapton-crescent, Sheffield.	1	1	0	—		
Westminster, Duke of, Eaton Hall	5	0	0	—		
	£96	13	6	£28	18	6
Royal Society Grant, per Prof. Herdman	—			50	0	0

LIVERPOOL MARINE BIOLOGY COMMITTEE.

Dr. IN ACCOUNT WITH ISAAC C. THOMPSON, HON. TREASURER. **Cr.**

1889.		£	s.	d.
To Balance due Treasurer, 31st December, 1888		2	1	1
,, Salaries of Curator and Assistant		60	10	0
,, Furnishing Rooms at Puffin Island Station		5	0	11
,, Repairs to Boats, &c.		1	19	4
,, Moorings at Puffin Island		4	16	6
,, Scientific Apparatus		1	17	3
,, Donkey		0	15	0
,, Steam Tug Co. for Tugs for Dredging		20	0	0
,, Postages and Carriage of Reports, Apparatus, Specimens, &c.		7	18	7
,, Paraffine Oil		1	3	0
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,, Turner, Routledge & Co.—Printing and Stationery		8	15	0
,, Do. Vol. II. Fauna L.M.B.C.	£32 8 0			
,, Lit. and Phil. Soc., 50 Copies Vol. I. do.	7 10 0			
	39 18 0			
Less Sales Vol. I. and II.	21 18 10			
		17	19	2
,, Advertisement (*Nature*)		0	7	9
,, Sundries		2	8	7
		£141	12	2
By Balance due Treasurer		£3	19	2

6—2

1889.		£	s.	d.
By Subscriptions, as per list	£96 13 6			
Less Arrears	2 2 0			
	94 11 6			
,, Donations, as per list	28 18 6			
	123 10 0			
Of which £35 17s 0d is for Endowment.	35 17 0			
		87	13	0
,, Grant from Royal Society		50	0	0
,, Balance due Treasurer		3	19	2
		£141	12	2
To Endowment Fund		£35	17	0

ISAAC C. THOMPSON,
HON. TREASURER.

Audited and found correct,
ALFRED LEICESTER.

LIVERPOOL, 31*st December*, 1889.

NOTE on SOME HABITS of CRUSTACEA.

By Alfred O. Walker, F.L.S.

[Read 13th December, 1889.]

One or two observations which I have made this summer in connection with Crustacea may be interesting. The first that occurs to me has reference to the common Woodlouse or Slater (*Oniscus asellus*, Linn.). I had frequently noticed these animals in my bath in the morning, they having fallen in during the night, when they were generally alive and creeping on the bottom, for (unlike insects) they always sink. I therefore tried the following experiment, showing that they can live over fifteen hours under water:—

July 25th, 1889: At 8 a.m. placed an *Oniscus asellus* in a phial $2\frac{1}{2}''$ deep × $1\frac{1}{2}''$ diam., wide-mouthed and uncorked, filled with river water (clean) nearly to the shoulder. The animal sank at once to the bottom, where it walked about, occasionally making vain efforts to climb up the side of the phial.—7 p.m.: Animal alive, but rather sluggish. Poured water off, without uncovering him, to within half an inch of the bottom, and again filled up to shoulder. Animal quite lively again, walking rapidly about the bottom and trying to climb up the side.—11.30 p.m.: Animal quite lively, walking about.—July 26th, 7.45 a.m.: Animal dead.

This is very strong evidence in favour of the evolution of *Oniscus* from the aquatic Isopoda, the half-marine half-terrestrial *Ligia oceanica* forming a connecting link.

An interesting fact, illustrating the ingenuity shown by more than one species of Crustacea in concealing themselves, came under my notice last summer. Having dredged a number of Amphipoda, I placed them in a vessel of sea water till I could examine them. Among them I noticed what seemed to be a piece of dead weed swimming rapidly about and occasionally falling to the bottom. Examination with a lens showed that the piece of weed was carried by an Amphipod (*Atylus swammerdamii*), which grasped it by the two first pairs of walking legs (peræopoda). When it came to the bottom the animal concealed itself beneath the weed, which was much larger than itself.

In connection with this habit of *A. swammerdamii*, it may be mentioned that another species, *Atylus falcatus* (Metzger), resembles the first named minutely in every respect but one, viz. that the first peræopod has the claw (dactylus) immensely developed, while at the base of the next joint are two or three strong blunt spines or tubercles into which the point of the claw fits. This would appear to give the latter species a great advantage over its congener in grasping an object for purposes of concealment. It is a rare species, but I have met with a few specimens this summer: I am not aware of its having been recorded as British yet.

In some of the Podophthalmata the same instinct has been observed, and especially among the Anomoura. All these have the last or hindmost pair of legs of a shrunken and apparently almost abortive form. They never appear to be used for walking, and are generally carried turned up on the back; but they are utilized by some species of curiously shaped, flat bodied Crabs (*Dorippe*) to carry the valve of a bi-valve mollusc over their backs, under which they can squat and hide. From this it is an easy transition through various stages to the Hermit Crabs (Paguridæ), which ensconce themselves altogether in a uni-valve shell, and use the curiously abortive hind limbs to cling to the inside whorls. My friend Surgeon Major Archer has seen crabs of the genus *Dorippe* protecting themselves (probably from the scorching tropical sun), at low tide, on the mud flats at Singapore, by carrying large leaves over their backs (Journal of Linn. Soc., vol. xx., p: 108).

REPORT on the LAND MOLLUSCA of PUFFIN ISLAND.

By Alfred Leicester.

[Read 13th December, 1889.]

In presenting this report on the land Mollusca of Puffin Island, I may remark that on account of the small size of the island the numbers to record cannot possibly be large, or the species very varied, still what species have been found are well represented. The collections were made in the autumn of 1887 and summer of 1889. Further time devoted to the search in the future may result in the discovery of a few additional forms, but it is not to be expected that many such will be found. So far two families only are represented, viz. Limacidæ by one species, and Helicidæ by fifteen species.

I have not yet made a very careful search on the mainland of Anglesey, around Penmon Point, or on the Great Orme's Head, but most of the species found on the island have also representatives on the mainland; whilst one noticeable form found commonly on the Great Orme's Head does not occur on the island, viz. *Cyclostoma elegans*, the only operculated land shell. It seems strange that not even a dead specimen should have been found on Puffin Island considering its proximity to the land, and this being so, it would appear that no communication can have existed for a long period, or else such a striking form would surely have left some trace.

The nomenclature I have used is that of Forbes and Hanley's "British Mollusca."

GASTROPODA.

PULMONATA.

Family: Limacidæ.

Limax agrestis, Müll.

Very common, especially after rain. No other slugs have been observed.

Family: Helicidæ.

Vitrina pellucida, Müll.

Only a few specimens found.

Zonites cellarius, Müll.

Fairly common, some good ones. No other *Zonites* found on the island, but another species, *Z. alliarius*, Mill., was obtained on the Great Orme's Head, when one specimen only was found.

Helix aspersa, Müll.

It is a strange fact that this common shell should only be represented by dead specimens, not even a single living one having been found on the island. The quantity of dead ones is very large, showing that the species must have been very common formerly. Most were found at the mouths of the rabbit holes. Both on Anglesey and the Great Orme's Head living specimens are found.

Helix nemoralis, L.

By far the most common land shell on the island, and some are very good examples. The Conchological Society of Great Britain and Ireland are now making each differently banded shell a distinct variety, which is to my mind a great mistake. The number of bands and colouring of this shell is certainly too slender ground to go upon in forming named varieties. Some shells have only one band half way round and two bands on the remainder. Many of the living shells are weathered to a greater or less extent, which may be accounted for by the very exposed situation of the island.

Helix hispida, L.

A few specimens found, also a good one on the Great Orme's Head.

Helix caperata, Mont.

Fairly common. This shell is also found on the Great Orme's Head.

Helix rotundata, Müll.

Very common, some specimens being rather large.

Helix pulchella, Müll.

Not very frequent.

Helix umbilicata, Mont.

On the first visit only one specimen was found, but since a fairly good number have been taken.

Bulimus acutus, Müll.

Very common. Some of the specimens are very strongly marked and are good examples of the species. They abound in the cliffs all round the island. This shell is very local in its distribution and variable in its markings.

Bulimus obscurus, Müll.

Only one dead specimen found on the island, but several on the Great Orme's Head.

Pupa umbilicata, Drap.

Also very freely distributed all round the island; there are, however, a good many dead specimens. No other *Pupa* noticed on Puffin Island or on the Great Orme's Head.

Clausilia nigricans, Mat. and Rack.

Very common, and the specimens large.

Zua lubrica, Müll.

Only one specimen, found by Mr. Gregory; no doubt there are more, but so far they have escaped notice.

PNEUMONOCHLAMYDA.

Family: Cyclostomatidæ.

Cyclostoma elegans, Müll.

This beautiful shell was found to be fairly common on the Great Orme's Head, and so far as I have read I have not noticed it recorded as having been found previously in this district.

NOTE on the STINGING HAIRS of *URTICA DIOICA*.

By R. J. Harvey Gibson, M.A., F.L.S.,
LECTURER ON BOTANY IN UNIVERSITY COLLEGE, LIVERPOOL,
AND
Miss Amy Warham, Student of Biology.

With Plate I.

[Read 14th February, 1890.]

The following observations were made by us in the hope of determining the nature of the substance in the stinging hairs of the genus *Urtica.* It may be well, by way of introduction, to quote the account given by De Bary.*

"We know of the erect stinging hairs of the Urticaceæ, Loaseæ, and other plants named above (page 60), which resemble one another so remarkably in structure and form, that the brittle point breaks off when touched, and that a fluid issues through the hole thus made which causes more or less slight inflammation when applied to the human skin, especially if it enters the small wounds caused by touching the hair itself. It is further known of this fluid that it has, like most cell fluids, an acid reaction, not alkaline as stated formerly.† On the fact that by distilling the nettle plant with sulphuric acid formic acid is obtained, the conjecture has been founded that the latter substance causes the phenomena of stinging.‡ But as a matter of fact nothing is known of the active substance, not even whether it is to be sought for in the acid fluid, or in the protoplasm."

De Bary also refers to a paper by Duval-Jouve, which he says however "gives no new information.§ We know of no more recent literature on the subject.

The structure of the adult stinging hair is too well known to need redescription. We may note, however, that two forms of hair occur on the nettle leaf, one type being

* "Comparative Anatomy of Phanerogams and Ferns," p. 68.

† P. de Candolle, "Physiologie," übers. v. Röper, vol. i., p. 193.

‡ Von Gorup Besanez, "Jour. f. Pract. Chemie," vol. xlviii., p. 181.

§ "Bull. Soc. Bot. France," vol. xiv., p. 36.

usually curved and simply pointed, whilst the other is nearly straight, considerably larger, has a swollen base, and exhibits the familiar bulb-like head. We figure the two varieties on Plate I. (figs. 1, 2, 3), and also the apex of the bulbous form under a high power in fig. 4. In addition to these, small glandular hairs occur consisting of a unicellular pedicel and a head composed of two, four or eight cells.

The basal part of the stinging hair forms a pedicel and is multicellular, the apical portion of which forms a cup supporting the stinging cell proper. The base of the stinging cell always shows the presence of abundant granular nucleated protoplasm, which is continued up the slightly tapering body of the hair to the extreme apex. Sap vacuoles occur in the base and body, but not in the apical region of the latter, nor in the bulbous head which is always filled with granular matter giving the reactions of protoplasm.

The epidermis at the base of the hair-pedicel gives with blue litmus a red reaction and with Congo-red a blue reaction, indicating the presence of a free acid. The hair itself in many cases does so also, but not by any means in all. The reaction when observed was confined to the base and body of the hair. It is by no means easy to detect the presence of any particular organic acid, especially one of a closely related series, in quantities so minute as those available in the nettle hairs.

In order that the following results may be as far as possible free from error, we have submitted them to the criticism of Dr. C. A. Kohn, Demonstrator of Organic Chemistry in University College, whose kind assistance in our work we gratefully acknowledge.

The rough method of distilling the leaves with sulphuric acid we rejected as liable to lead to fallacious results. We tested first of all with individual hairs, carefully removed so as to avoid injury to the hair, with a solution of nitrate of silver in ammonium hydrate. On slightly warming, a granular precipitate appeared in some of the hairs, which, with reflected light, gave a bright metallic lustre, pointing to the deposition of metallic silver. From the rapidity of this reaction we were inclined to suspect the presence of tartaric rather than of formic acid. We then tested hairs with lime-water, with the result that a dense opaque white precipitate made its appearance in some hairs, which precipitate proved to be soluble in acetic acid. This confirmed our suspicions of the presence of tartaric acid. At the same time we found no evidence of the presence of formic acid in the hair itself. We therefore at first felt inclined to consider tartaric acid as the irritant sought for. Tartaric acid injected hypodermically produces symptoms similar to those produced by normal contact with fresh nettle stings.

We next endeavoured to ascertain why the free acid reaction was forthcoming in some hairs and not in others. The only explanation we can suggest is, that in excess of lime, calcium tartarate is formed, which however would be soluble in free tartaric acid when the latter was in excess. This may explain the presence normally, especially in old hairs, of a granular opaque white precipitate soluble in acetic and other acids. The wall of the hair cell is strongly cuticular, the apical fourth and the bulb however resist boiling in sulphuric acid, and, even after being submitted to red heat, leave an incombustible residue retaining the appearance of the unaffected tip.

By a simple mechanical arrangement we then watched the effect of normal contact between the skin and the stinging hair beneath the magnifying power of 50 diameters. The bulb at the end of the hair springs at almost a right angle from the body. If the contact be gentle the bulb is cracked off at a junction with the body, the sharp edge of the latter apparently causing the wound. If the contact be rough the hair is broken across the middle instead, and the wall in that part seems not to be sufficiently firm to cause any puncture in the skin. There flows out immediately a portion of the granular contents of the apex of the hair, which, from its being stainable by dyes and from its chemical reactions, appears to be as truly protoplasmic as the contents of the hair generally. The contents of the vacuoles were not expelled in all the cases which we observed. We conclude from this that the irritant is to be sought for in the protoplasm itself. We hazard no suggestion as to its chemical nature, but reserve our conclusions for a further note, which we desire to present so soon as our investigations are concluded.

The mechanism of expulsion we judge to be as follows. The pedicel cells form a reserve of turgid parenchyma, from which the base of the stinging hair receives a supply by osmosis. Internal pressure in the latter is thus set up, which is relieved by the breaking off of the bulb head, some of the apical contents being at the same moment expelled by elasticity of the cell wall.

Explanation of Plate I.

Fig. 1. Stinging hair of *Urtica dioica*, × 50.
Fig. 2 and 3. Ordinary epidermal hairs, × 50.
Fig. 4. Glandular hair, × 50.
Fig. 5. Base of the stinging hair, × 350.
Fig. 6. Apex of the stinging hair, × 500.

Since reading this paper we have met with an elaborate monograph by Gravis, on the Anatomy of *Urtica* (*Mem. Acad. Roy. de Brux. t. xlvii. pp. 1—256*). He distinguishes three types of hair, 'poils glandulifères,' 'poils piquants' and 'poils urticants,' but does not go into the physiological action of their contents.

NOTE on some MUMMY CATS, &c., from EGYPT.

By Professor W. A. Herdman, D.Sc.

[Read 14th February, 1890.]

Upwards of 200,000 mummied Cats and other animals were brought into Liverpool early in 1890, and were sold to be ground down for manure. They came from the great cat cemetery of Beni-Hasan, in Central Egypt, where there was formerly a celebrated temple of Pasht, the Cat-Goddess. When the mummies arrived in Liverpool they were all in a fragmentary condition, and the few specimens which I was able to secure for the Zoological Museum of University College, were chiefly heads of cats, ichneumons, a dog, and some fragments of crocodile. The cat heads are in various conditions, some being shapeless masses thickly coated with bitumen, others having fragments of the mummy cloth still wrapped round them, and others again being simply dried, the fur (in all cases of a yellowish colour) being present, and the ears, nose and vibrissæ perfect. Mr. Clubb has succeeded in stripping the integument and subjacent tissues off several of the dried specimens so as to produce fairly good skulls, which can be measured and compared with those of their probable descendants, our present domestic cat. Mr. W. R. Melly has kindly measured for me as many of the mummy skulls as could be procured and several skulls of the common cat from the College collection, with the general result that the Egyptian skulls are about one-fifth larger than those of our present cat. Taking an average domestic cat's skull (A) as being 100 mm. in length, then the average length of our mummy skulls (B) is nearly 120 mm.;

and this greater size is almost entirely in the anterior region, in front of the coronal suture. In A, from occipital crest to coronal suture is 48 mm. and from coronal suture to premaxillary symphysis 52 mm., while in B the same measurements are 50 and 70 respectively. The jaws, both upper and lower, are larger and stronger in B than in A, and the zygomatic arch is fully one-fifth wider, the numbers being 30 mm. and 24 mm. respectively. So that the ancient Egyptian cats were notably larger in the facial region, the jaws (and canine teeth) and the zygomatic arch. Some individual variation was noticed in regard to the first small premolar teeth of the upper jaw, both in the Egyptian and the domestic cats. Normally there is one small anterior premolar on each side, but some specimens have two on each side, some none, and one skull has one on the one side and none on the other. So the premolar dental formula varies from $\frac{2}{2}$ to $\frac{4}{2}$. The single mummy dog's skull in the collection also has an abnormal dentition, there being an additional premolar present in the upper jaw on each side, and one premolar absent in the lower jaw on the left side. The mummy ichneumons probably belong to the species *Herpestes ichneumon* (Pharoah's rat), which is known to have been worshipped and protected by the Egyptians. In regard to the species of the cat remains, it is said that four out of the fifty so-called species of *Felis* have been found mummied in Egypt, viz., *F. chaus* (the jungle cat of India), *F. bubastes*, *F. caligata*, and *F. maniculata* (the gloved cat). It seems very doubtful that the true *F. chaus* of India has been found in Egypt, and I cannot obtain any satisfactory account of *F. bubastes*, while *F. maniculata* of Rüppell is apparently a synonym of *F. caligata*, and to this species our specimens from Beni-Hasan probably belong.

REPRODUCTION among the LOWER FORMS of VEGETABLE LIFE.

By Alfred W. Bennett M.A., B.Sc., F.L.S.,
LECTURER ON BOTANY AT ST. THOMAS'S HOSPITAL, LONDON.

With Plates II. and III.

[Read 14th March, 1890.]

In this paper which I have been honoured by being asked to lay before you, I propose to invite your attention to some phenomena connected with the modes of reproduction which we meet with in some of the lower forms of vegetable life, especially the green forms belonging to the lower Algæ and the Schizophyceæ.

One of the most simple, and at the same time one of the most abundant, of these forms of life is the common *Protococcus pluvialis*, which occurs in two conditions, the motile and the resting state (fig. 1). I must ask your pardon for describing so familiar an object, but you will see my purpose presently. In the resting or palmella-condition each individual consists of a nearly spherical or somewhat polygonal cell, usually from 40 to 50 microns in diameter, with a thick cell-wall of cellulose. The change to the active state takes place by the protoplasm withdrawing itself from the cell-wall, and escaping in the form of an ovoid mass, provided with two very long and slender vibratile cilia or flagels, a pulsating vacuole, and a pigment-spot or "eye-spot." After being driven about rapidly for a considerable period with an apparently spontaneous motion, the motile protococcus comes to rest, loses its flagels, becomes encysted, and enters into its resting condition, in which it may remain dormant for a considerable period before again passing into the motile state. Now there are two points in the life-history of *Protococcus* to which I wish to call your attention, and to which we will recur hereafter, viz., the motility, and the presence, when in a motile condition, of the pigment-spot which reminds one so closely of the corresponding "eye-spot" in the Flagellate Infusoria. In order for the *Protococcus* to be able to divide and multiply in the palmella-form, it seems to be necessary that it should pass through the motile stage; and it appears also to be in this motile stage that the pigment is always first developed, though it may increase so greatly when in the palmella-condition as entirely to mask the chlorophyll, and give the whole organism a blood-red tint, in which state it is known as *Hæmatococcus*.

Protococcus may be taken as a type of the lowest development of the Protococcoideæ, those Schizophyceæ in which the endochrome consists ordinarily of chlorophyll-bodies not masked by any pigment, and which has its highest developments in such forms as *Sciadium*, *Dictyosphærium*, and *Characium*, with a much more differentiated thallus, and where the ordinary mode of propagation is by flagellate zoospores.

We will now turn to another of the lowest groups of vegetable life, the Cyanophyceæ, distinguished by the invariable presence of a blue-green coloring matter dissolved in the cell-sap, though this may again sometimes be masked by a brown or red pigment. In, at all events, the lowest of the Cyanophyceæ distinct chlorophyll-bodies have not been detected.

One important and very interesting distinction between the Cyanophyceæ and the Protococcoideæ is that, in the former group we have at present no well-authenticated instance of the formation of flagellate zoospores ; the only known mode of propagation is by some form of division or fission. In some of the lowest genera of Cyanophyceæ we have, notwithstanding the absence of motile swarm-cells, a more or less well-marked power of apparently spontaneous motion. In *Microcystis* (fig. 2). a minute organism common in stagnant water, and in *Aphanothece*, which often forms large gelatinous masses on wet rocks or on submerged plants, this is confined to a swarming motion of the rudimentary blue-green cells or pseudocysts within their common envelope. In *Cœlosphærium*, (fig. 3) a beautiful and common object in bog-pools, nearly spherical, but with the blue-green pseudocysts projecting above the surface of the globe, the whole organism moves about with considerable rapidity with a kind of rolling motion. It should be mentioned with regard to this lowest order of Cyanophyceæ, the Chroococcaceæ, that some algologists who have devoted to them much time and very careful observation, have adopted the view, not only that many of the genera hitherto regarded as distinct are genetically connected with one another as different states or vegetative conditions of the same organism ; but that most, if not all of them are, so to speak, embryonal stages in the development of Algæ belonging to a much higher type. *Microcystis* has even been regarded as a resting stage of *Euglena*.

It is instructive to notice how, in the higher families of the Cyanophyceæ, that motility is localised, which, in the Chroococcaceæ, is characteristic of the entire organism. In these higher filiform families of blue-green Schizophyceæ, the Nostocaceæ, Rivulariaceæ, Scytonemaceæ, and Oscillariaceæ, the ordinary mode of propagation is by means of hormogones, strings composed of a small number of cells which detach themselves from the rest of the filament, escape from their mucilaginous envelope, move about with a creeping motion, then come to rest, and develop into new individuals (fig. 4). In the remaining families of filiform Cyanophyceæ, power of spontaneous movement is confined to these hormogones; the Oscillariaceæ, on the other hand, derive their name from the peculiar oscillating movement of the entire filament; but according to Borzi, one of the most careful observers of these forms of life, the power of motion is limited to the reproductive period.

We now turn to a group of Algæ much higher in development, the Desmidiaceæ. Desmids have two modes of multiplication, a sexual process of conjugation, and a non-sexual mode of propagation by division. It is the phenomena connected with the latter to which I wish to direct your attention; and we may take as an example a species of the familiar genus *Staurastrum* (fig. 5). When division is about to commence, the endochrome retreats slightly from the band or "isthmus," which connects the two half-cells with one another, and the two halves then separate, retaining their connection only by a narrow band formed by the gradual broadening of the isthmus; this isthmus is after a time divided into two by a transverse septum midway between the two half-cells, and parallel to the constriction between them. The endochrome now passes out of each original half-cell into the half of the band in connection with it; and at the same time the half-band bulges, and, growing rapidly, assumes the form and appearance of an original half-cell. Fresh formation of chlorophyll is at the same time taking place in it, and the half-band becomes a complete half-cell. The whole of these processes have taken place in the course of a few hours, or even less; and we have now two individuals attached to one another, and frequently remaining in connection for a considerable period, until at length they separate. In the spiny species of *Staurastrum*, from which our illustration is taken, it is very curious to watch the very rapid appearance of the spines on the half-bands while their development into half-cells is progressing. There is another very interesting phenomenon connected with the process which I do not remember to have seen recorded by any other observer. Desmids, as it is well known, have a power of apparently spontaneous motion through the water, somewhat resembling that of Diatoms, the cause of which is still involved in considerable obscurity. During the whole time that the division is taking place, the organism displays remarkable activity in this respect, not so much a motion of translation as a peculiar pulsating or "shuddering" movement, reminding one of an animal subjected to external or internal irritation. When the new formation is completed, it becomes perfectly quiescent.

We have seen that the higher Protococcoideæ are propagated by means of flagellate zoospores; and this is the ordinary mode of non-sexual multiplication in all the higher orders of Algæ, except the Conjugatæ, the Fucaceæ, and the Florideæ; with the Phæosporeæ and the higher Confervoideæ they suddenly cease; and no organs of this nature are to be met with in the Characeæ or any of the higher classes of Cryptogams. In all Cryptogams, except the Florideæ, the Conjugatæ, some Fungi, and the Mycetozoa, the male agent in the process of impregnation is a flagellate antherozoid, bearing, in the lower orders, a close resemblance to a zoospore, but attaining a much more complicated structure in the more highly organised forms. Zoospores and antherozoids are alike generally characterised, as far as my knowledge goes, by the presence of the red "eye-spot" or pigment-spot to which I have already alluded; though I am doubtful whether attention has been sufficiently directed to this point to affirm it as a universal law.

The presence of bright coloring in connection with the reproductive process is a widely diffused and remarkable phenomenon in the vegetable kingdom; whether appertaining to the male element before fertilisation, to the subsidiary structures associated with the female organ, or to the organ which results from that process; and the cause of this coloring opens out a very interesting problem in vegetable biology. No doubt in the example which is most familiar to us, the bright coloring of petals, we have an easy explanation in most cases, in the attraction of insects to assist in the act of pollination. But this explanation is clearly not applicable in all instances. How, for example, does it explain the bright scarlet of the styles of the hazel? or the beautiful rose-color of the opening inflorescence of the larch? or the bright pigment of the cone-scales of the Scotch fir? All these plants are fertilised exclusively by the agency of the wind, and in none of them can we have recourse to the theory of survival, since, on any hypothesis of evolution, both Corylaceæ and Coniferæ must be regarded as archaic forms anterior in development to those orders of Angiosperms which have a brightly colored perianth. Or, to take organisms still lower in the evolutionary scale:—how are we to account for the brilliant red of the sporange of *Sphagnum*? or the bright coloring of the modified leaves which surround the male inflorescence in the same group of mosses? or the equally brilliant coloring of the "globule" or antherid in the Characeæ? or the brilliant scarlet of species of *Peziza* or *Boletus*? These problems I leave with you without any attempt at solution.

That the particles of protoplasm should be in a state of peculiar molecular activity at the period when any process of multiplication is taking place, or is about to take place, and in the organs especially connected with it, is not a matter of surprise.

The close resemblance between a zoospore and an antherozoid belonging to one of the lower families of Algæ has already been pointed out. Both are biflagellate masses of protoplasm with a contractile vacuole, and, at least usually, a pigment-spot. And there can be no doubt that in the zoospore we have the ancestor of both male and female elements in the higher plants. A large number of the families of Algæ produce two kinds of swarm-cell, resembling one another in every respect except size. The larger swarm-cells or megazoospores are purely non-sexual, germinating directly into new individuals. The smaller swarm-cells, microzoospores, or more correctly zoogametes, have but very little independent power of germination; before they can develop into new individuals, two of them must coalesce; and this process of conjugation or the union of two equivalent or nearly equivalent cells, whether motile, as in the case of zoogametes, or stationary, as in the conjugation of *Spirogyra* or the desmids, is universally regarded as the lowest phase of a truly sexual process of reproduction.

Let us now examine the phenomena of multiplication in the three lowest classes of true Algæ, the Cœnobieæ (including Volvocineæ, Hydrodictyeæ, Pediastreæ, Pandorineæ, and Sorastreæ), the Multinucleatæ (embracing Siphoneæ, Botrydiaceæ, Dasycladaceæ, and Siphonocladaceæ), and the Confervoideæ Isogamæ (comprising Confervaceæ, Pithophoraceæ, Ulotrichaceæ, and Trentepohliaceæ). In most of the genera of these orders we have two modes of multiplication, non-sexual by zoospores, and sexual by zoogametes. The sexual and non-sexual propagating elements are alike naked flagellate swarm-cells, with a pigment-spot and pulsating vacuole, indistinguishable from one another except in size, the former being much smaller than the latter. The gametes moreover have always two flagels, the zoospores not unfrequently four. They may be produced on the same or on different individuals. In the gametes there is to all appearance absolutely no external differentiation between male and female elements, though a rudimentary physiological differentiation is undoubtedly occasionally observable in the fact that swarm-cells produced in the same parent-cell will not conjugate. The ordinary course of reproduction is varied in some genera by departures which are exceedingly instructive.

In the Ulotrichaceæ there is a gradual transition between zoospores and zoogametes, the only constant difference between the two organs being that the former have four, while the latter have only two flagels. Those zoogametes which do not conjugate may germinate directly, but then give rise to smaller plants than those which spring from the zoospores. The two kinds of swarmspore are never produced in the same cell, but in different cells of the same individual. The same is the case also with the Trentepohliaceæ or Chroolepideæ. In *Vaucheria* (Siphoneæ) the zoospores, which are of considerable size, instead of being biflagellate, are completely surrounded by a fringe of delicate flagels. In *Botrydium* (Botrydiaceæ), on the other hand, the zoospores are uniflagellate. In *Dasycladus* (Dasycladaceæ) the biflagellate zoospores conjugate only if produced from different individuals. In *Hydrodictyon utriculatum*, the water-net, (Hydrodictyeæ) from 30,000 to 40,000 minute biflagellate zoogametes are produced in the same cell or gametange; and in this case swarm-cells from the same gametange undoubtedly conjugate, conjugation having been observed to take place even within the gametange, more than two sometimes uniting together. The larger zoospores are quadriflagellate. In *Pandorina* (Pandorineæ) (fig. 6), the only known mode of sexual reproduction is by the conjugation of zoogametes within the parent-colony; among the throng of swarm-cells pairs may be seen approaching as if they were seeking one another ; these ultimately come into contact by their pointed extremities, and coalesce. In *Eudorina* (Volvocineæ) (fig. 7), which resembles *Pandorina* very much in appearance, a much greater advance is shown in the differentiation of the sexual elements. The colony or cœnobe is, in both these fresh-water Algæ, a nearly spherical body, rapidly propelled through the water by the numerous long, delicate flagels which project through its envelope. In *Pandorina* these belong to the zoogametes, in *Eudorina* to the female elements only, affording, therefore, one of the rare instances in the vegetable kingdom of zoospheres, *i.e.*, of female cells endowed with motility by means of flagels. The male elements or antherozoids are elongated fusiform bodies of protoplasm, closely resembling those of *Volvox*, and formed in special daughter-colonies entirely enclosed within the cœnobe, which may, therefore, be called antherids. The antherozoids swarm round the zoopheres until their flagels become entangled in those of the latter ; they then force their way through the gelatinous envelope of the oogone, and, finally, coalesce with the zoospheres. A most instructive observation has, however, recently been made by Dangeard, that the oospheres occasionally act as zoogametes, coalescing with one another. In the familiar *Volvox* (Volvocineæ) (fig. 8) we have a further most interesting advance. The female elements have lost their flagels, and become ordinary motionless oospheres, which are impregnated by the flagellate antherozoids within the cœnobe, very much in the same manner as in *Fucus*. *Volvox* is also propelled, like *Pandorina* and *Eudòrina*, rapidly through the water by means of delicate flagels projecting through the gelatinous coat of the cœnobe; but these flagels belong to a peripheral layer of cells which have no power either of conjugation or of germination, affording the very unusual phenomenon of cells endowed with spontaneous motion, which have, nevertheless, as far as is known, no direct reproductive function. To this very remarkable phenomenon reference will again be made hereafter.

That the antherozoids of the higher Cryptogams—and therefore the pollen-grains of Flowering Plants—are genetically descended from zoogametes, and these again from zoospores, we have further conclusive evidence in the various processes of reproduction in that interesting class of sea-weeds, the Phæosporeæ. In this class the swarm-cells are alike in their external appearance and motile properties, each being provided with two large and slender flagels, one of which is directed in front, the other dragged behind, in the swarming movement. They are, however, partly non-sexual zoospores, partly sexual zoogametes. The sporanges (or gametanges) of the Phæosporeæ are of two kinds, unilocular and plurilocular, although intermediate conditions between the two occur. The unilocular sporanges are comparatively large structures, usually pear-shaped, ovoid, or nearly spherical in form, the contents of which break up into a large number of zoospores, which escape through an apical or through a lateral opening. The multilocular sporanges are elongated bodies, having somewhat the appearance of jointed hairs, segmented usually in the transverse direction only, but sometimes in both. From each of the cells is produced a single zoospore; when mature, either each of these escapes separately from its parent-cell, or the septa become absorbed and all the zoospores escape successively through a common ostiole at the apex. Some species of Phæosporeæ possess both kinds of sporange, while in others only one or the other kind has at present been detected. There is in some cases a further differentiation, in the two kinds of sporange being always produced on different individuals; or, when borne on the same individual, they mature at different times. No difference is observable in size or form between the swarm-cells produced in the two kinds of sporange; but those produced in the unilocular sporanges appear to be in all cases non-sexual zoospores, germinating directly into a new individual, while those from the multilocular sporanges are in some instances zoogametes with sexual functions. In *Ectocarpus siliculosus* (fig. 9), a not uncommon seaweed of our coasts, the multilocular sporanges present the first rudimentary indication of a sexual differentiation. Some of these, after a very short period of swarming, become fixed to a solid substance by the apex of that one of the two flagels which is directed in front in the swarming movement. Both flagels gradually disappear, the gradual contraction of the anterior one causing the protoplasmic body of the swarm-cell to become closely attached to the solid substance. During this period it appears to exercise an attractive force on other swarm-cells which have been swarming around it, and, during the very short period that it is in a receptive condition, coalescence takes place between the female and one of the male zoogametes. The impregnated gamete immediately clothes itself with a cell-wall, and proceeds to germinate. It should, however, be noted that both male and female gametes are capable of germination without conjugation, though the resulting new individuals are then always weakly, and soon perish.

In *Ectocarpus pusillus* and *Giraudia sphacelarioides* we have possibly a still earlier condition, in which there is apparently no differentiation between male and female gametes; they conjugate while still both in the swarming condition, as is the case in some of the green Confervoideæ. In the Cutleriaceæ (fig. 10), we have a further step in advance. The female elements, here known as oospheres, and the male elements, now termed antherozoids, are again naked biflagellate masses of protoplasm with an orange-red pigment-spot, but the former are many times larger than the latter. These oospheres, or zoospheres as they may not inaptly be termed, afford another of the few instances known in the vegetable kingdom of undoubted female elements endowed with active motion. This, however, lasts only for a short time; and it is not until they have lost their flagels and come to rest that the antherozoids approach them; and the absorption of a single antherozoid into the oosphere is then sufficient to impregnate it. Here again it is stated that in *Cutleria multifida* the oospheres are capable of germination without being fertilised, while the antherozoids have entirely lost this power. *Zanardinia*, which belongs also to the Cutleriaceæ, produces, in addition to these sexual organs, non-sexual zoospores in unilocular sporanges; while in *Aglaozonia reptans* these latter are the only kind of reproductive body known. In the Dictyotaceæ, which are placed by the best authorities among Phaeosporeæ, a further advance is established. The flagellate zoospores have disappeared, and are replaced by non-motile tetraspores,* as in the Florideæ; and the female reproductive bodies are from the first motionless non-flagellate masses of protoplasm.

* Recent observations of Mr. T. Johnson, at present unpublished, appear to cast some doubt on this statement.

Let us now endeavour to draw some general conclusions from the array of facts I have endeavoured to present to you. It is usual, in works on Physiological Botany, to distinguish between two kinds of multiplication in the vegetable kingdom,—reproduction and propagation; understanding by the former the production of an entirely new individual by a sexual process, by the latter the continuance, by a process of special vital activity, of some particular portion of the old individual. This distinction is a very useful one in practice; but we must be careful not to push it too far. In Classification we have long learnt that Nature refuses to be mapped out into squares like a chess-board, and that in any natural system of taxonomy the various classes and divisions must slide into one another by insensible gradations. So in Morphology and Physiology. It is all very well to say:—This organ is constructed in such or such a manner, and is fitted for such or such a purpose; while another organ has a totally different structure and a totally different purpose. No doubt it is so where differentiation has made great progress. But just as, in the lowest types of life, we find archaic forms from which the most complicated might have been derived, so also we find rudimentary structures with many functions, or even capable of taking up, according to circumstances, totally different characters. Plasticity is the great feature of a low type of life. We have seen, in such families as the Confervaceæ, an apparent identity in structure between the male and female elements. And, what is more instructive still, we find, in a considerable number of families of green Algæ, that the zoogametes which do not conjugate, whether male or female, are capable of germinating into new individuals; though, as far as observation has gone, the new individuals thus produced are always weakly, and generally soon perish.

A very striking illustration of this plasticity of function is afforded by some recent remarkable observations by Dr. G. Klebs on the water-net, *Hydrodictyon utriculatum*, which, as far as I am aware, have not yet been published in any English journal. *Hydrodictyon* exhibits both kinds of multiplication,—the conjugation of zoogametes, and non-sexual propagation by zoospores; and, in ordinary course, presents an illustration of the phenomenon known as alternation of generations; *i.e.*, after a series of non-sexual zoospore-generations, the cycle is completed by the production of a sexual generation, viz., of zoogametes which conjugate to produce a zygote. In any individual *Hydrodictyon*-net, all the cells are apparently equivalent, *i.e.*, are adapted to produce either zoospores or zoogametes. Klebs found that the tendency to produce one or the other of these structures is largely a question of nutrition; and that, in a single net consisting of equivalent sister-cells, some of the cells can be excited, by external conditions, to develop zoospores, others to develop gametes; the production of the former being, in all cases, absolutely dependent on light. His general conclusion is that there is not in *Hydrodictyon* any true and necessary alternation of sexual and non-sexual generations, such as is displayed in the Muscineæ and Vascular Cryptogams; but that every cell of the net has the capacity for producing either kind of organ; and that it depends on external conditions which of the two forms of reproductive organ is brought into existence; favourable conditions tending, as a rule, to the production of non-sexual, unfavourable conditions to the production of sexual organs. A similar law, that a superabundant supply of nutrition is favourable to the development of the vegetative or alimentary, at the expense of the reproductive organs, is not unknown in the higher branches of the vegetable, nor, I believe, in the animal kingdom.

And here I cannot avoid the temptation of travelling somewhat beyond the limits to which I originally proposed to confine myself in the present paper, and to refer for a short space to phenomena observed in the animal kingdom, specially to the remarkable observations of Professor Weismann, and the brilliant deductions which he has drawn from them, contained in his recently published volume of Essays, and in a most interesting article in "Nature" for Feb. 6th. Into the wide-reaching problems discussed by Weismann it is entirely beyond my province and beyond my competence to enter. I wish merely to call attention to one of his conclusions:—that the old idea of an essential difference, at all events of an opposition, between male and female elements, between so-called "sperm-cells" and "germ-cells", must be abandoned; that "they are essentially alike, and differ only so far as one individual differs from another of the same species"; and that "fertilisation is no process of rejuvenescence, but merely a union of the hereditary tendencies of two individuals." This view, the correctness of which I do not propose to discuss, he supports from the results of experiments which he regards as demonstrating the extraordinary fact that, even in animals as high in the scale as the Batrachia, the "sperm-nucleus" can be made to play the part of "ovum-nucleus", and *vice versâ;* it being possible to produce a free-swimming larva in the formation of which a "germ-nucleus" has taken no part. These remarkable facts may be regarded as complementary to the much more frequent phenomenon of parthenogenesis, familiar to all students both of animal and vegetable biology.

Whether or not we adopt Weismann's view with regard to the higher developments of the process of fertilisation, I think the facts I have brought before you lead beyond controversy to the conclusion that all these higher developments have had their first origin in the union of two motile flagellate masses of protoplasm between which there is no apparent differentiation; but that very early as we ascend in the evolutionary scale, these two masses of protoplasm exhibit differences which become gradually more and more marked as they develop into what we term male and female cells; the latter very soon losing their flagellate character, becoming quiescent, and increasing in size; the former going through the various stages of a biflagellate zoogamete indistinguishable from a zoospore, and the multi-flagellate antherozoid of the higher Cryptogams; and being finally replaced by the pollen-grain of Flowering Plants, with its power of putting out pollen-tubes.

Are we not then justified in regarding every process of fertilisation simply as a modification of a process of nutrition, the conveying to a potential germ of some property which it has not derived from its own ancestors, but which gives it greater completeness and power of developing into a new individual? In connection with this view it is interesting to observe that, although the flagellate condition is especially characteristic of cells which are concerned directly with a process of reproduction, this is not universally the case; instances are known in which the functions of flagellate cells are purely nutritive. It would lead me beyond the limits of my present subject to speak in detail of the remarkable phenomena connected with the uniflagellate swarm-cells of the Myxomycetes, which display extraordinarily active powers of ingestion and digestion of both fluid and solid materials, while in their motile condition before coalescing into a plasmode. On this subject I can only refer to a valuable paper by Lister recently contributed to the Linnean

Society. We have an example more germane to our theme in the sterile flagellate cells which form the peripheral layer in *Volvox*. (See fig. 8, *C*.) These closely resemble ordinary zoospores in structure, except that the gelatinous membrane which envelopes each of them is pierced by a number of fine canals filled by extensions of the protoplasmic endochrome; these swarm-cells being therefore connected with one another and with the interior of the cœnobe by an intricate network of protoplasmic threads. These flagellate cells are, in fact, the assimilating cells of the colony; they obtain the nutritive materials from the water, and pass it on through this protoplasmic network to the reproductive cells in the interior of the cœnobe, and after having performed this function, wither up and die.

It is by a careful study of the life-history of some of these lowest forms of vegetable life that the best opportunity is afforded of learning something more than we know at present of the laws of adaptation by means of which—whether purely through natural selection, or through an inherent tendency to the transmission of adaptive peculiarities—that extraordinary fertility of form has been developed which characterizes both the fauna and the flora of these latter days in the history of our globe.

Explanation of Plates II. and III.

Fig. 1. *Protococcus pluvialis* Ktz.; *a*, motile condition, *b*, palmella-condition (× 400).

Fig. 2. *Microcystis marginata* Men. (× 400).

Fig. 3. *Cœlosphærium Kützingianum* Näg. (× 400).

Fig. 4. *Schizothrix anglica* Benn.; *a*, hormogone (× 400).

Fig. 5. *Staurastrum teliferum* Ralfs; *a*, *b*, two stages in the process of division (× 400).

Fig. 6. *Pandorina morum* Ehrb.; *a*, swarming cœnobe, *b*, zoogametes conjugating (× 500).

Fig. 7. *Eudorina elegans* Ehrb.; *a*, zoosphere, *b*, anthero-zoid (× 400).

Fig. 8. *Volvox globator* Ehrb.; *A*, cœnobe (× 200); *a*, antherids, *b*, oogones, *c*, flagellate peripheral cells; *B*, oosphere and antherids within oogone; *C*, flagellate peripheral cells (more highly magnified).

Fig. 9. *Ectocarpus siliculosus* Ktz.; *a*, female zoogamete, gradually losing its flagels *b*, male zoogametes swarming round female zoogamete, *c*, stages in the coalescence of the zoogametes (× 800).

Fig. 10. *Zanardinia collaris* Crouan; *a*, zoosphere, *b*, an-therozoids, *c*, coalescence of antherozoid and oosphere. *d*, fertilised oosphere (× 800).

MONSTRILLA and the CYMBASOMATIDÆ.

By I. C. Thompson, F.L.S.

With Plate IV.

[Read April 11th, 1890.]

In a paper entitled "Notes on the Genus Monstrilla" by Mr. G. C. Bourne, in the current number of the "Quarterly Journal of Microscopical Science" (February 1890), the author refers to the various recorded species belonging to this genus, of which he considers my genus *Cymbasoma* to be a synonym.

As stated by Mr. Bourne, previous to the capture of the solitary specimen to which I gave the name *Cymbasoma** *rigidum* no similar animal had been recorded since that described by Claus as *Monstrilla heligolandica* in 1863. I subsequently found *Cymbasoma* in tow-nettings taken about Malta, and again in British waters on two occasions off Puffin Island as well as in Clyde gatherings. Mr. Sinel has also taken a number of specimens at Jersey, Mr. W. S. McMillan has found it at Torquay, and several specimens were taken by Canon Norman and Mr. Bourne at Plymouth. So that there has been no lack of material recently upon which to discuss the correctness of previous observations; and I may say at the outset that I concur in the general conclusion of Mr. Bourne that, under our existing knowledge, the various species seem to belong to one genus, and that the name *Cymbasoma* must be withdrawn in favour of *Monstrilla;* but, as I shall show further on,

* Linnean Journal, vol. xx., p. 145.

I cannot see that Mr. Bourne has sufficient grounds for merging the family Cymbasomatidæ in the Corycæidæ.

It was when engaged in examining a mass of material which I had collected about the Canary Islands that I came across the solitary specimen alluded to above, and I took the precaution of consulting with Dr. G. S. Brady before venturing to form for its reception the genus *Cymbasoma*. I did not overlook Dana's genus *Monstrilla* as Mr. Bourne supposes, but having the support of Dr. Brady's experienced opinion I was like him misled by the probably inaccurate figure (Ray Society Monograph, vol. III. p. 38) taken from Lubbock's solitary specimen, which has since been lost. This figure gives a large rostrum to the animal and omits one or more of the body segments; and being taken from a male bears little or no general resemblance to my specimen, a female, the sexes of this genus being very dissimilar in form and appearance. With male specimens now before us I think there is a considerable probability of the identity of Lubbock's *Monstrilla anglica* with my *Cymbasoma herdmani.*

It is somewhat unaccountable that previous to my capture of the specimen off Teneriffe in 1887 not a single specimen of *Monstrilla* should have been recorded as taken anywhere for a quarter of a century, especially as Claparède reports that it was not at all rare on the Normandy coast when he described *Monstrilla danæ* in 1863* and as it has been so frequently met with during the last two years. My experience is that the striking appearance of the animals of this genus render them readily conspicuous whenever they are in material under examination. The fact that they are destitute of posterior antennæ, mandibles, and maxillæ, as well as foot jaws, at once distinguishes

* Beobach. Anat. Entwick. Wirbellos. Thiere, Leipzig, p. 95.

them, and must lead any observer to almost mistrust his eyes as did Claparède—for how can it live with apparently no means of obtaining nutriment? Its internal anatomy further bears out the supposition that its digestive powers must be very limited, for it is quite destitute of any alimentary canal; the small mouth discernable in some specimens opening directly into the body cavity.

From the entire absence of mouth organs one would naturally surmise that the animal was a sucking parasite dependant for nutriment upon its host, and the cylindrical proboscis ending in a mouth possessed by some species lends countenance to this view. But against this it must be noted that this mouth is very rudimentary or entirely absent in the males of most of the species (they also being devoid of eyes); and further, as noted by Claparède and by Bourne, all the specimens of *Monstrilla* hitherto recorded have been free swimmers near the surface. So there is no sufficient justification for the parasite theory, and for the present I am inclined to think with Bourne that "possibly this creature may present an analogy with the Ephemeridæ, and the adult may be preceded by a predaceous larva supplied with mouth parts and an alimentary tract, which, after a succession of rapid ecdyses, developes into the mature sexual form, whose only function is that of reproduction."

Bourne classifies the known forms of *Monstrilla* into six species:

1. *Monstrilla rigida*, I. C. Thompson.
2. *Monstrilla longispinosa*, Bourne.
3. *Monstrilla danæ*, Claparède.
4. *Monstrilla viridis*, Dana.
5. *Monstrilla heligolandica*, Claus.
6. *Monstrilla anglica*, Lubbock.

To this list I have now to add—

7. *Monstrilla longicornis*, n. sp.,

a form of which I recently took one specimen near Puffin Island, and which differs specifically from the six previously enumerated. Considering our still very limited knowledge of the genus it is by no means improbable that further investigation may reveal the necessity of dividing *Monstrilla* into two genera. Indeed Claparède says*: "One can still be doubtful whether the Chinese *M. viridis* and the European species really belong to the same genus."

Bourne ingeniously founds a system of classification of the species of *Monstrilla* upon the number of setæ occurring on each division of the caudal segment,

viz., A, Three setæ on each furcal member.
B, Six setæ ,, ,, ,,

Claparède, however, in his exceedingly beautiful plates, figures (l. c. fig. 2) the male of *Monstrilla danæ* with four setæ on each furcal member, Mr. Bourne's supposition being that "he has omitted to count them carefully." I think it is probable that Claparède is quite correct on this point both from the fact of his generally careful description and because my specimen of *M. longicornis* has undoubtedly four setæ, and only four, on each furcal member. If, therefore, the number of caudal setæ is found to be sufficiently constant for this basis of classification to be retained, it will be necessary to add a further division:—

C, Four setæ on each furcal member,

containing *M. danæ* of Claparède and my new species *M. longicornis*. I suspect, however, that it will be found necessary to discover some more stable basis for the classification of the various species composing this most remarkable and altogether puzzling genus.

* loc. cit. p. 96.

Of specimens of the various species of *Monstrilla* I have had no experience beyond some half-dozen which I have in all collected. Three of these, all females, are clearly *M. rigida*, I. C. Thompson. Two others, both males, though very unlike in general appearance, agree structurally for the most part with and are probably different stages of *M. anglica*, Lubbock. Examined with a high form ($\frac{1}{16}$ Obj. Gundlach) these reveal some points apparently overlooked by other observers. The spines situated on the 2nd and 3rd joints of the antennæ of the specimen which I take to be the more mature of the two have finely serrated edges (Pl. IV. fig. 5.) The fifth and apical segments have one feathery plume on the inner side of each (fig. 3). The setæ of the swimming feet and caudal segment are all finely plumose. The first abdominal segment bears a symmetrical genital appendage curiously like the tail fin of a fish, (see fig. 6). It is a good deal different in form from Bourne's fig. 9, though doubtless of the same nature and function—whatever that may be.

The last specimen of *Monstrilla* which I have found differs entirely in several points from any hitherto described species. From its very long antennæ I propose to name it *Monstrilla longicornis*, and describe it as follows:

Monstrilla longicornis, n. sp. (Plate IV., figs. 1, 2, and 4).

Length from apex of antennæ to caudal segment 1-15th of an inch. Antennæ almost the same length as the entire cephalothorax, having six segments; the first and basal segment as broad as long; the length of the second about four times as long as the width, bearing a spine about the centre on inner side and several spines near its apex; the third segment about twice as long as broad, bearing several spines; the fourth about the same length as the second, with an enlargement about the centre bearing spines. Between the fourth and the penultimate there is a decided hinge which leads me to conclude that the specimen is a male; the fifth segment rather longer than the third and terminated by several setæ; the sixth is rather shorter than the fifth and much narrower, bearing at the apex one long and one short spine and one or possibly more setæ. Cephalothorax composed of five segments covered all over with very fine black dots. No appearance of any eye; mouth subcentral, ventral, near the middle of first body segment; mouth organs entirely absent. Setæ of swimming feet apparently non-plumose, the edges being wavered or uneven (fig. 2). Fifth pair of appendages in the form of two long setæ springing from short protuberances. Abdomen composed of four segments, the first bearing a genital appendage terminating in two short lateral spines. Furcal members each terminated by four apparently non-plumose setæ, the edges of which are marked with regular dots which may possibly be the scars of lost hairs (fig. 4).

A single specimen of this striking species was taken by tow-net off Puffin Island in November 1888. The length of the antennæ and the finely dotted surface readily distinguished it from any other species.

The systematic position of the genus *Monstrilla* is not at all an easy matter to decide upon, but I fail to see that Bourne has given any good grounds for placing it among the Corycæidæ, where it was originally placed by Claus.

A comparison of the two families, Corycæidæ and Cymbasomatidæ, will show that they have indeed very few points in common.

Corycæidæ. (Thorell, G. S. Brady.)	Cymbasomatidæ. (I. C. Thompson.)
Body subpyriform.	Body elongated, boat-shaped.
Abdomen elongated, much narrower than the cephalothorax.	Abdomen scarcely narrower than cephalothorax.
Anterior antennæ 5—7 jointed; alike in both sexes, short.	Anterior antennæ 4—6 jointed; different in the sexes, the male on both sides being thickened and geniculated.
Posterior antennæ simple, 3—4 jointed, forming a strongly clawed prehensile hand. Mandibles, maxillæ, and first pair of foot jaws present, but destitute (or nearly so) of palps. Posterior foot jaws prehensile, and in the male powerfully clawed.	Posterior antennæ and gnathites entirely absent. Rudiments of gnathites present in larval specimens. Mouth circular, at end of cylindrical process on ventral surface of cephalon, and leading into a short pharynx; remainder of digestive tract aborted.
First four pairs of feet adapted for swimming, 2 branched.	First four pairs of feet adapted for swimming, 2 branched.
Fifth pair of feet rudimentary alike in both sexes, rarely absent.	Fifth pair of feet rudimentary in both sexes.

Corycæidæ.—*Cont.* (Thorell, G. S. Brady.)	Cymbasomatidæ.—*Cont.* (I. C. Thompson.)
Small median eyes and usually two large lateral eyes.	Females have usually a single median eye with two lenses on dorsal side of head, and a third median lens on ventral side. Males of most species have no eyes.
Ovisacs usually two.	No ovisacs. Ova are deposited upon strong double genital setæ.

Bourne lays stress upon the eyes "the character of the antennæ, the reduction of the mouth parts, and the habit of the animals." But in the matter of antennæ *Monstrilla* certainly more nearly resembles the Harpacticidæ than the Corycæidæ, while in the condition of the mouth parts it is difficult to see the similarity, and as to the habit of the animals and the appearance of the eyes they are entirely different in the two cases.

There is but little similarity between the families Pontellidæ and Corycæidæ, and yet Claparède was inclined to place *Monstrilla* in the former. His remarks on this point may be thus translated :—

"Especially with the Pontellæ and perhaps also with the Setellæ as stated already by Dana, the relationship cannot be denied. *Monstrilla* is, so to speak, a *Pontella* provided with a proboscis and therefore degraded to the Cormostomata. This comparison is so natural that as soon as a *Pontella* rushed through the field of my microscope I thought I saw a *Monstrilla* and groped after it. I cannot help regarding this circumstance as a fresh support for the view so ingeniously supported by Steenstrup and Lütken, according to which view the parasitic Crustaceans do not form a special order, but only represent the parasitic Lophyropoda. Every type of Lophyropod would, according to this theory, furnish a sucking sub-species. That is to say, it might appear here as a form of Gnathostoma, and there as a form of Cormostoma. . . . I now find in the example before us a new warranty for the correctness of the above mentioned theory. Namely, *Monstrilla* appears as the Cormostoma or Siphonostoma form of a type, the Gnathostoma form of which is to be looked for in the genus *Pontella*."

I am not aware that the further knowledge during the past quarter of a century since these words were written has in any way gone to substantiate the theory here indicated, and there certainly seems no better grounds for placing *Monstrilla* among the Pontellidæ than among the Corycæidæ. Finally Lubbock's *Baculus elongatus** which has been compared with *Monstrilla* by more than one author is probably a young stage of *Lernæa branchialis*.†

For the present therefore I think that while *Cymbasoma* must be merged in *Monstrilla*, we are justified in separating (as I did in my paper in the Linnean Journal for 1887) this remarkable group of species from the other Copepoda as a distinct family, the Cymbasomatidæ, having the characters given above on p. 121; and the natural position of this family seems to be close to the Artotrogidæ, the proboscis of *Monstrilla* corresponding to the siphon of the Siphonostoma.

*Trans. Linn. Soc., vol. XXIII, 1860.

†Compare Proc. Biol. Soc., L'pool. vol. III. pl. VIII. fig. 6.

Explanation of Plate IV.

Fig. 1.	*Monstrilla longicornis*, n. sp., male,	× 250
Fig. 2.	Do. seta of swimming feet,	× 750
Fig. 3.	Feathery plume on inner side of apical segment of antennæ of male *Monstrilla anglica*, Lubbock.	× 750
Fig. 4.	Seta of furcal members of *M. longicornis*,	× 750
Fig. 5.	Spines on second and third segments of antennæ of *M. anglica*, male,	× 750
Fig. 6.	Genital appendage on first abdominal segment of *M. anglica*, male,	× 750

On CROSS- and SELF-FERTILIZATION among PLANTS.

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[Read 9th May, 1890.]

In discussing the question of cross- and self-fertilization, investigators have confined their attention almost, if not entirely to the Phanerogamia. Müller makes a brief reference to the Thallophyta, Bryophyta, and Vascular Cryptogams,* but more by way of pointing out the hiatus in our knowledge with regard to the phenomena of fertilization among the Cryptogamia than of attempting to fill it.

The Darwinian aphorism "Nature abhors perpetual self-fertilization" has not been accepted by all botanists as a complete statement of the case, or as the expression of a law of universal or even of very wide application. Müller himself, though a strong supporter of the efficacy of cross-fertilization, follows Axell in admitting and indeed urging the importance of self-fertilization in certain groups of plants, e.g. those with cleistogamous flowers. Meehan † again considers that self-fertilized plants have existed quite as long on the earth's surface as cross-fertilized forms, and that the injuriousness of self-fertilization which Darwin emphasised does not express a fact, since self-fertilized are in every way as healthy as cross-fertilized plants. Henslow goes even farther. In the conclusion

* *Die Befruchtung der Blumen.* Eng. Ed. p. 14.

† Proc. Amer. Assoc. Adv. Sc. vol. xxiv., p. 243.

of his elaborate essay *On the Self-fertilisation of Plants** he summarises the results he has arrived at in the following words :—

"So far from there being any necessarily injurious or evil effects resulting from the self-fertilization of plants in a state of nature, they have proved themselves to be in every way the best fitted to survive in the great struggle for life."

The Orchidaceæ are frequently appealed to as a typical group where the phenomena of "cross-fertilization" are particularly well seen. On the other hand certain species belonging to the genera *Ophrys*, *Habenaria*, *Dendrobium* and others are mentioned by Darwin himself as being adapted for "self-fertilization"; and the investigations of Forbes † demonstrate that even in this group, so greatly modified in many cases to bring about "cross-fertilization" the Knight-Darwin Law has many and important exceptions.

Must we then throw overboard our belief in the necessity for "cross-fertilization" as a law of nature so far as the plant world is concerned, or retain it so modified or loaded with exceptions as to render it doubtful whether it be a law at all? There are two obvious considerations which must be taken account of before answering this question. The first of these is what do we understand by the phrases, "cross-fertilization" and "self-fertilization"? I believe that the diversity of opinion on this question is in reality due to an inaccurate use of these terms. The second point, to my mind of even more importance, is that in the discussion of the subject appeal has been made to one only of the two sub-kingdoms of the Plant world.

* Linn. Soc. Trans. 2 Ser. Bot. vol. i., p. 396.

† *On the Contrivances for ensuring Self-fertilization in some Tropical Orchids.* Linn. Soc. Jour. Bot. xxi., p. 538.

The essential feature in the process of fertilization is the fusion of the nuclei of the male and female reproductive cells. *Self-fertilization* must then mean the fusion of the nuclei of male and female reproductive cells, these cells being produced on the same individual. In other words self-fertilization involves hermaphroditism. *Cross-fertilization* on the other hand must mean the union of the nuclei of male and female reproductive cells, where these cells are produced in reproductive organs on separate individuals. Cross-fertilization does not of course necessitate unisexuality; two hermaphrodite individuals may fertilise each other, and in proterandrous and proterogynous forms cross-fertilization must of necessity take place.

To take instances. The fertilization of the 'archicarp' of *Eurotium aspergillus-glancus* by the 'pollinodium', both of which are borne by the same hypha, is an undeniable instance of self-fertilization. The fertilization of the ovum of the diœcious Alga *Fucus vesiculosus* by the sperm is in like manner an undeniable instance of cross-fertilization. Again the fertilization of the ovum of the hermaphrodite prothallus of a typical member of the Polypodiaceæ by the sperm (antherozoid) (assuming that the prothallus is not proterandrous) may be considered as an example of self-fertilization. In the case of certain members of the Osmundaceæ where the prothallus is diœcious, the union of the sperm and ovum must be considered as a case of cross-fertilization. Manifestly, it follows that among the Heterosporous Pteridophyta cross-fertilization must be of absolutely universal occurrence, since the contents of the microspore and megaspore correspond to male and female prothalli respectively, though greatly reduced in size and feebly differentiated. Once accept this conclusion I see no way of escape from the admission of the *absolutely universal occurrence of cross-fertilization in the Phanerogamia.* Every Phanerogam is heterosporous, the pollen grain being morphologically a microspore, the embryosac a megaspore. Vines* in briefly referring to this point postulates the necessity for the existence of "a certain degree of *sexual affinity* between the sexual reproductive cells" and argues that "though Phanerogams are strictly speaking diœcious, yet they are not so physiologically." He explains his position by assuming that since the sexual generation has become rudimentary and merged in the asexual, "the oosphere and pollen grain stand in the same physiological relation to each other as two gametes produced by the same plant, a relation which is too close to admit, in many cases, of fertile sexual process taking place between them."

In criticism of this view it may be said that it is impossible to ignore the accumulation of facts brought forward of late years in support of the view that so-called "self-fertilization" is at least of quite as common occurrence as "cross-fertilization" among Phanerogams, and that the assumption made by Vines as above quoted is too sweeping. Further, it can hardly be said that the pollen grain of a Phanerogam is "merged in the asexual" generation to a greater extent than is the microspore in the asexual *Selaginella* plant. As for the embryosac, it is true that the organic connection between that structure and the megasporangium (nucellus) is closer than that which exists between the megaspore and the asexual *Selaginella;* still the mere isolation or non-isolation of the megaspore in the sporangium can hardly be looked upon as having that profound signification by inference postulated by Vines.

***Physiology of Plants,* p. 648.

Again if we are to accept such observations as those of Henslow, Meehan and others on the high degree of productivity resulting from the "self-fertilization" under certain conditions of flowers normally self-sterile, are we to conclude that the alterations brought about in the environment have so profoundly altered the physiological value of the reproductive cells, cells it is to be noted already mature and ready for "cross-fertilization"?*

Prof. D'Arcy Thompson in his preface to the translation of Müller's work says: "I have throughout used *fertilization* in preference to the ungainly word *pollination*, to imply application of pollen to the stigma without definite reference to the result of the act; that is to say, I have in ordinary cases translated *Bestäubung* and *Befruchtung* by the same word." But the two processes are, as every ons knows, essentially distinct. The application of pollen to the stigma is merely the approximation of the microspore to the megaspore and does not by any means involve fertilization. "Pollination" is the term adopted by most leading botanists for the application of pollen to the stigma. Goebel,† for instance, is careful to emphasise the importance of the distinction between the two processes.

If then we accept the fact that Phanerogams are of necessity cross-fertilized from their heterosporous condition, the further problem, Is cross-pollination a universal law or not? is left for solution. Into that question I do not intend to enter.

The whole question of cross- versus self-fertilization in plants has, it seems to me, scarcely yet been touched; for as I have pointed out the very numerous investigations I

* Henslow. Linn. Soc. Trans., l. c., p. 325.

† Outlines of classification and Special Morphology of Plants, p. 306.

have referred to all deal with the subject of cross- and self-pollination—a very different matter. The wider and more fundamental problem indeed cannot be answered until investigations have been made in this relation on the phenomena of fertilization among the Cryptogams.

Generally speaking it may be said that cross-fertilization is at least possible in all cases where motile male cells are formed; where, on the other hand, as in the majority of Fungi and not a few Algæ, the male element is not motile and is produced in close proximity to the female organ, self-fertilization seems alone possible. Perpetual self-fertilization, it is interesting to note, has apparently had no "injurious" effect in such close breeding forms as *Eurotium*, *Phytophthora*,—forms which are amongst the most vigorous and widely distributed Fungi with which we are acquainted.

Experiments may show that no universal law can be laid down, but that for each group, perhaps for each genus or even species, one or other condition is the more efficacious—in other words, that in attempting the solution of this as in so many other problems, we are driven back to the consideration of the physiological and morphological properties of protoplasm, the elucidation of which has been well termed the supreme problem in Biology.

THIRD REPORT upon the NUDIBRANCHIATA of the L.M.B.C. DISTRICT.

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With Plates VI., VII., VIII., IX.

[Read May 9th, 1890.]

Since the last Report, published a year ago *, a large number of Nudibranchs have been collected at Puffin Island, Hilbre Island, and in other parts of the district; and although no species previously unrecorded have been found, new localities have been added for some of the rarer species, and a number of additional observations upon habits and variations have been made. We have continued some of the anatomical and histological investigations on the structure of the cerata commenced last year, and have instituted a comparison between the conditions of the various dorso-lateral ridges and processes in the different genera. We also record here some experiments made in the fish tanks of the Liverpool Aquarium with the object of testing the theory proposed by one of us that the chief function of the cerata or dorsal papillæ is, according to their condition, to contribute to the inconspicuous and protective appearance of the animal or, in other cases, to render it conspicuous and warn predaceous animals of some special offensive property.

* Proc. Biol. Soc., L'pool, vol. iii., p. 225.

This report is divided into three parts :—(1) the systematic account of the species, (2) some remarks upon the epipodial nature of the cerata, and (3) an account of the experiments with fishes. The usual tabular view of the distribution of the recorded species throughout the district, brought up to date, will be found on p. 146.

Part I. Systematic Account of the Species.

NUDIBRANCHIATA.

A. PYGOBRANCHIA (=HOLOHEPATICA).

Family Doridæ.*

Archidoris tuberculata, Cuvier.

We have several times lately found this common species lying in hollows of large sponges (*Halichondria panicea*), the Nudibranch being in such cases very completely hidden from observation. Garstang † has recently noticed this protective resemblance in specimens found at Plymouth, and Giard ‡ has referred to it in discussing the Nudibranchs at Wimereux, on the coast of Normandy. In 1888 we described § a remarkable specimen which was so coloured as to resemble exactly the lining of the rock-pool in which it lived.

Lamellidoris bilamellata, Linnæus.

This is the commonest species of Dorid in the Mersey, and although richly coloured with yellow and brown, so

* We consider the form "Doridæ" preferable to "Dorididæ" as it avoids confusion with the family Doridiidæ formed for the genus *Doridium*.

† Jour. Mar. Biol. Assoc., vol. i. no. 2, p. 174.

‡ Bull. Sci. de la France, &c., t. xix., p. 492. Giard had also pointed out some years before (Arch. Zool. éxpér., t. ii., 1873, p. 487) that this and a few other species sometimes resemble the compound ascidians upon which they live.

§ Proc. Biol. Soc., L'pool, vol. iii., p. 13.

as to be a striking object in a white dish or a vessel of clear water, it is quite inconspicuous on the dark purple-brown rocks spotted with patches of adhering mud, sand, small algæ and zoophytes found in this neighbourhood. We were much impressed with this on a recent visit (March, 1890) to Hilbre Island when we found that a reef of rock we were exploring had a number of specimens of this species scattered over it which were not at first noticed because of the perfect manner in which their colours blended with those of the surroundings.*

Lamellidoris proxima, Ald. and Hanc.

We have taken this again at Puffin Island and Hilbre Island, and Dr. Hanitsch found it at Port Erin, Isle of Man, in April, 1890.

Acanthodoris pilosa, O. F. Müller.

Found again at Hilbre Island, March, 1890—colour dark grey. Transverse sections of this species bring out very clearly that the large papillæ on the dorsal surface are much more prominent on the sides than along the middle line of the back (Pl. VI. fig. 5).

Family Polyceridæ.

Goniodoris nodosa, Montagu.

Found at Port Erin, Isle of Man, in April, 1890, by Dr. Hanitsch. We have made use of specimens of this species for an enquiry into the condition of the epipodial ridges (Pl. VI. fig. 6) which will be discussed below.

Polycera quadrilineata, O. F. Müller.

Dr. Hanitsch obtained some specimens at Port Erin, Isle of Man, in April, 1890. We have found this species an important transition form, in the condition of the

* In this connection see the experiments on fishes given on p. 152, and the remarks on colour on p. 162.

dorsal ridges and epipodial processes, between *Goniodoris* and *Ancula*.† The anterior part of the body in the region of the rhinophore shows in transverse section (Pl. VI. fig. 7, *e.p.*) a prominent lateral ridge which becomes considerably lower as it is traced back (Pl. VI. fig. 8, right side), and then rises again at the sides of the branchiæ (Pl. VI. fig. 8, left side, and fig. 9) and immediately behind them to form prominent cerata comparable with those of *Ancula* (Pl. VI. fig. 10). These posteriorly placed cerata of *Polycera* contain numerous large glands (Pl. VII. figs. 3 and 4) which we shall have to refer to again in connection with *Ancula* (p. 136).

Ancula cristata, Alder.

This species was found by Dr. Hanitsch at Port Erin, in April, 1890, and we took it in extraordinary profusion at Hilbre Island in March, 1890. On one reef of rocks especially, a little way above low water mark, there must have been many thousands of specimens present. For yards it was impossible to walk without treading on them and handfuls were readily collected by scraping the specimens together from the mud-covered rocks. Many of these were kept alive and used for the experiments with fishes at the Aquarium described below.

The variation in size and colouring of this species at Hilbre is very great, and the larger specimens are almost invariably white, light grey or almost colourless, while the smaller ones are more or less conspicuously ornamented with bright yellow. This species is very slimy, and a number of specimens put together in a bottle very soon form a

† Garstang (loc. cit. p. 181) has already pointed out that the cerata of an allied form, *Idalia aspersa*, are plainly homologous with the ridges of *Goniodoris* &c., and the epipodial folds of *Doris*; and has expressed his belief that their homologues are to be found in *Tritonia*, *Lomanotus* and *Eolis*. See also, Herdman, Quart. Journ. Micr. Sci., vol. xxxi., p. 42.

reticulum of mucus with mud and entangled foreign bodies in which they remain hidden. In the natural state the mucus seems chiefly on the foot and especially at its posterior end, each individual having a slimy string attached to the end of the tail by which it is anchored. This no doubt accounts for the manner in which the animal is able to live on exposed rocks in the wash of the tide. We have several times watched specimens of *Ancula* in a few inches of water when there was a strong tide running past the rocks and waves dashing on them and noticed that they were swayed backwards and forwards in the water but were securely anchored by their tails.

Transverse sections through the body show that at least three different sets of glands connected with the integument are present. First there are the mucus-secreting goblet cells in the ectoderm which are abundant over the whole surface (Pl. VII. figs. 5 and 6, *g.c.*); then there are the distinct glands in the foot (Pl. VII. fig. 5, *f.gl.*) which are large and extend for a considerable way into the mesoderm; and finally there are special glands which are placed chiefly on the side of the body in its posterior part (Pl. VII. fig. 6, *gl'*.), and in large masses occupying the apices of the cerata (Pl. VII. fig. 8, *gl'*).

The foot glands are multicellular pyriform masses opening by narrow ducts on the surface of the foot (Pl. VII. figs. 5 and 6, *f.gl*). The cells are distinctly nucleated and granular, and stain deeply with picrocarmine. The special glands on the sides of the body and tail consist of large single cells of spherical or pyriform shape which are generally aggregated into clumps. These cells are distinctly nucleated, but the nucleus is sometimes displaced to one side and the greater part of the cell is occupied by a clear or faintly granular secretion (Pl. VII. fig. 6, *gl'*). Ducts are not so obvious as in the case of the foot glands. At the apices of the cerata the glands are much more distinctly arranged in ovate or pyriform masses (Pl. VII. figs. 7, 8, 9) and there are usually distinct ducts (Pl. VII. fig. 9, *gl'*). The cells are smaller, are invariably filled with a clear secretion, and the nucleus is displaced to the side. We find that the cerata are occupied by large blood spaces (the ceratal sinuses, Pl. VII. figs. 7 and 8, *b.s.*) exactly like those of the cerata of *Dendronotus arborescens*.*

Ancula is not protectively coloured; and as it has no cnidophorous sacs, its bright white and yellow colouring and conspicuous appearance on dark rocks seemed for a time inexplicable. From our experiments we have come to the conclusion that it is distasteful to fishes (see below, p. 155), and possibly it is the secretion of these large compound glands at the apices of the cerata which is of an offensive nature.

In *Polycera quadrilineata* (Pl. VII. figs. 3 and 4) the cerata terminating the lateral ridges on the body, which we regard as representing the cerata of *Ancula*, contain numerous glands. These are simple pyriform sacs filled with large polygonal granular cells which stain deep crimson with picrocarmine (Pl. VII. fig. 3, *gl*). These glands open between the ectoderm cells by long narrow tubular ducts (Pl. VII. fig. 4).

In *Ancula* the large glands in the cerata are somewhat different from those of *Polycera quadrilineata*. The masses are not so regularly placed and shaped, and the cells are not so granular, but seem to a large extent filled up with a clear secretion, while the nucleus is displaced to one side of the cell. And whereas in *Polycera* the glands extend nearly all over both sides of the cerata, there being

* Compare our last report, Proc. Biol. Soc., L'pool, vol. iii., Pl. xii. fig. 2.

only a narrow basal tract free from them, (Pl. VI. fig. 9), in *Ancula* they are confined to the terminal one-third or so of the cerata. Possibly these glands, both in *Polycera* and *Ancula*, correspond to those found in a similar position in *Aplysia* (Pl. VII. fig. 1), viz., along the edges of the epipodia. In *Aplysia punctata*, however, these epipodial glands are smaller and not so conspicuous, those of the under surface of the mantle edge being relatively larger and more numerous (Pl. VII. fig. 2).

B. CERATONOTA (= CLADOHEPATICA.)

Family Dotonidæ.

Doto coronata, Gmelin.

Dredged in Turbot Hole, off Puffin Island, August, 1889.

With the view of determining the structure of the cerata, and especially the meaning of the little pigmented projections which give them their turretted appearance (Pl. IX. fig. 1), we have made a number of serial sections both longitudinal and transverse. The hepatic cæca in the cerata are very large and are branched and swollen, so that usually several large hepatic cavities are found cut in each section (Pl. IX. fig. 1).* Between the hepatic cæca and the ectoderm we find almost a continuous layer of gland cells which stain deeply with picrocarmine and are arranged in elongated clumps lying parallel with the ectoderm and usually two or three cells thick (Pl. IX. fig. 3, *gl.*). On the pigmented projections the columnar ectoderm is found to become rapidly cubical and then almost squamous (Pl. IX. figs. 2 and 4, *k*), while the dome-shaped cavity below the thin ectoderm is nearly filled up

* For the general relations of the hepatic cæca in the cerata to the parts of the liver in the body see Herdman, Quart. Jour. Microsc. Sci., vol. xxxi., p. 51, and pl. ix.

with gland cells amongst which are found one or more small cavities.

Vayssière * has described in *Doto cinerea*, and briefly referred to in *D. coronata*, the presence of remarkable large unicellular glands on the papillæ of the cerata which he considers as offensive organs comparable with the cnidocysts of the Eolididæ. Vayssière finds that these cells when mature are able on slight pressure to emit a delicate tube filled with a finely granular fluid, which escapes from a slit in the end of the tube, and may be regarded as a poison serving to defend the *Doto* against enemies.†

Our figures (Pl. IX. figs. 2, 3 and 4) are of course taken from preserved specimens, where no doubt there has been a certain amount of contraction, but the sections certainly give us the impression that the large cells are arranged in distinct masses or glands containing a central cavity (Pl. IX. figs. 2 and 4) and opening to the exterior at the apex of the little papilla where the epithelium becomes low. From Vayssière's figure ‡ it appears that in *Doto cinerea* the epithelium remains columnar all over the summit of the papilla. We do not find in our specimens any trace of the "urticating cells" filled with minute fusiform spicules found by Vayssière in *Doto cinerea*.

Family Eolididæ.

Facelina (*Acanthopsole*) *coronata*, Forbes.

We find that in this species, which we have been investigating since the last report, the apex of the hepatic cæcum in the cerata is connected with the cnidophorous sac by a long narrow tube very much as in *Facelina drummondi* (see Pl. IX. fig. 8). The cnidophorous sac

* Ann. du Mus. d'Hist. Nat. de Marseille, t. iii., mem. 4, p. 104, 1888.

† loc. cit., p. 105. ‡ loc. cit., pl. vii. fig. 133.

narrows gradually at its lower end and passes over into the connecting tube which is bent upon itself in a sigmoid curve. Fig. 6 shows a section in which hepatic cæcum (*h.c.*), connecting tube (*c.d.*) and cnidophorous sac (*c.s.*) occur together all cut transversely. The large cells or cnidocysts in which the thread-cells lie (fig. 6, *c.s.*) are distinctly nucleated and contain each a very large number of cnida. They get much smaller at the upper and lower ends of the sac and pass gradually into the ordinary ectoderm cells on the one hand and the cubical or low columnar cells of the connecting duct on the other.

The cnida are of elongated fusiform shape and are slightly curved* (fig. 7). None were seen in the exploded state. At the junction of the connecting tube with the apex of the hepatic cæcum the cubical epithelium passes gradually into the glandular hepatic cells, and there appears to be no distinct sphincter present. Figure 5 shows the very narrow opening of the hepatic cæcum into the lateral branch of the liver (*l.l.*) leading to the posterior end of the stomach.

Facelina (*Acanthopsole*) *drummondi*, Thompson.

A number of specimens were found at Hilbre Island on September 9th, 1889, at extreme low water.

The remarkably long curved connecting duct between the cnidophorous sac and the hepatic cæcum in this species is shown in Pl. IX. fig. 8, *c.d.* Pl. IX. fig. 9 shows the

* These are evidently the forms described by Vayssière as the reniform nematocysts (Ann. du Mus. d'Hist. Nat. de Marseille, Zool. t. iii., Mém. 4, p. 40, 1888); we have not found the second kind described as oviform. Bergh, in his recently published admirable account of the Cladohepatic Nudibranchs (Zoolog. Jahrbüch., Bd. v. 1890), seems to consider it still doubtful whether more than the one kind of cnida is really produced in the cnidophorous sac, but Vayssière's figures show very distinctly, in the case of *Coryphella landsburgi* at least, unbroken cnidocysts containing two distinct kinds of cnida, large reniform and small pyriform.

appearance of the hepatic cæcum in the living condition, and fig. 10 shows some of the pigmented yellow (*a*) and red (*b*) liver cells set free.

Coryphella rufibranchialis, Johnst.

This species is considered to be a synonym of *Coryphella landsburgi* by Trinchese, Vayssière and others, but we are convinced of its distinctness. In *C. rufibranchialis* the white zone on the cerata is very wide, and the cnida differ from those of *C. landsburgi* (see Pl. VIII. figs 2 and 9.) It has been added to the Fauna of Puffin Island by Mr. Thompson who collected three specimens on the south spit in April, 1890.

As this is a common species in this neighbourhood, and we have been able to examine a number of very fine specimens, we give the following notes taken from the animal in the living condition :—

The body is white and less translucent than in *Facelina coronata* and many other Eolids ; it is more solid and fleshy-looking. The front of the foot is prolonged laterally to form a pair of conspicuous curved processes. The tail is very long and tapers to a fine point. The largest specimens we have taken at Hilbre Island during the last year measure 4·5 cm. in length.

The dorsal tentacles are of the same white colour as the body. They are tapering and are not laminated, but are irregularly corrugated along their edges. There is a little opaque white pigment scattered over their tips.

The oral tentacles are of the same form, length, and colour as the dorsal tentacles. In one of our specimens we found the left oral tentacle bifurcating into a pair of long slender divergent branches with very sharp points.

The cerata are large and awkward looking, and the animal has a habit of erecting them in a bristling manner and of waving them about energetically with a somewhat jerky motion. The colour of the hepatic cæca in the cerata is from a bright brick-red to vermillion and is quite opaque; while the surrounding integument ("sheath" of Alder and Hancock) is colourless and transparent. There is a ring of opaque white pigment on the surface near the apex (Pl. VIII. fig. 1, *pg.*) The cerata are placed indistinctly in rows which are placed very close together and are 18 to 20 in number. There are about 6 cerata in each row, the smallest being as usual on the outside. Some of the smaller cerata have little or no colour, and in one of our specimens we found one of the largest cerata near the middle of the body to be perfectly clear and colourless—apparently the hepatic cæcum was absent.

The hepatic cæca in this species are very distinctly lobulated (Pl. VIII. figs 1, 3, 4 and 5). In some cases it might be said that short branches are present, thus leading in the direction of the distinctly branched cæca of *Doto*. Figure 3 shows one of the cerata of *Coryphella rufibranchialis* in longitudinal section and exhibits the well marked lateral lobes or short branches of the cæcum, while fig. 5 shows the condition, and arrangement of the red (*r*) and yellow (*y*) pigmented masses, in part of a slightly squeezed living specimen.

The broad ring of superficial pigment near the tip of the cerata hides the greater part of the cnidophorous sac (Pl. VIII. fig. 1, *pg.*) allowing only the apex and the wide base to be seen. The sac is large and of elongated pyriform shape, and has a very muscular wall. The cnidocysts are long and narrow and rather numerous. They nearly meet in the centre of the sac (Pl. VIII. fig. 4, *c.c.*) The connecting tube between the cnidophorous sac and the hepatic cæcum is so short as to be reduced to a mere opening (see Pl. VIII. fig. 1, surface view, and fig. 4, section), on the edges of which the smaller basal cnidocysts are seen to pass gradually over into the hepatic cells. The cnida, which are very numerous, are large and of nearly globular form (fig. 2) like those of *Facelina drummondi*, and the thread is coiled transversely to the longer axis of the cell.

Coryphella landsburgi, Ald. and Hanc.

We found four specimens of this rare species at the north end of Hilbre Island, on March 21st, 1890. This is apparently the first time it has been taken in the district since the two original specimens recorded by Byerley in 1849 and 1853.* Our specimens were obtained at extreme low water of a twenty foot tide, and at least two of them were attached to *Flustra foliacea*.

The length of the largest specimen when extended was 1·5 cm.; and the colouring was very brilliant, the body and tail and the tentacles, both oral and dorsal, as well as the surface layer of the cerata being of a bright lilac, or from that to a violet tint, while the central part of the cerata varied from a bright brick red to a vermillion colour, very much as in the case of *Coryphella rufibranchialis*. Under a low power the characteristic lilac colouring is seen to be in a granular condition, and is due to a large number of rounded pigment cells scattered closely over the surface layer of the mesoderm (Pl. VIII. fig. 10).

The cerata are arranged in groups. Commencing at the anterior end there are first four rows closely placed, then two rows, then four sets of single rows having six cerata in each row. The larger cerata are long and tapering. Near the tip of each is found an incomplete ring of opaque white pigment placed upon the surface and obscuring the median portion of the cnidophorous sac (Pl. VIII. fig. 7, *pg*). There is also a little opaque white pigment

* See our first Report in vol. i. of "Fauna," p. 274.

scattered over the tips of the dorsal and oral tentacles. The eyes are very distinct, and are placed some way behind the bases of the dorsal tentacles. Sections however show that they are sessile upon the cerebral ganglia.

The cnidophorous sac is pyriform in outline, the upper end being pointed while the lower wider end communicates with the apex of the hepatic cæcum by a short straight tube (Pl. VIII. fig. 7). The wall of the cnidophorous sac is unusually muscular, and while one of the animals was under observation in the living condition we saw a large number of the cnida expelled with force from the terminal opening (Pl. VIII. fig. 8.) in the exploded or evaginated condition. The cnida are large (measuring 0·028 mm. in length and 0·01 mm. in breadth) and are of an ellipsoidal shape (Pl. VIII. fig. 9).* The thread is distinctly seen to be coiled along the axis of the cell and not transversely to it as in *Facelina drummondi* and other species. When evaginated the thread is seen to be provided with numerous long sharp spines placed alternately so as to give rise to a zig-zag appearance (Pl. VIII. fig. 9).

Galvina picta, Ald. and Hanc.

We collected half a dozen specimens of this species at Hilbre on September 9th, 1889, and several on March 21st, 1890; and Mr. A. O. Walker dredged a specimen in Colwyn Bay in February, 1890. It appears to be becoming more common in the district.

Figure 11 on Plate IX. shows a transverse section through the tip of one of the cerata of this species. On the inner side of the large ectoderm cells is found a thin layer of connective tissue (*mes.*), then an irregular series of blood sinuses, then another thin layer of connective tissue, and then, occupying the centre of the section, is

* Described by Vayssière as reniform (loc. cit., p. 78.)

the cnidophorous sac (*c.s.*) with its wall formed of large cnidocysts (invaginated ectoderm cells) packed full of cnida. The sac is rather long, the cnidocysts are very distinct and not numerous, and the cnida are of elongated rod-like form with the thread coiled transversely to the long axis of the cell.

Cratena concinna, Ald. and Hanc.

We obtained this species for the first time during the recent cruise of the "Hyæna" (May, 1890). It was recorded many years ago by Collingwood, from the neighbourhood of the Mersey. We dredged three specimens off Lleiniog in the Menai Straits, between Puffin Island and Beaumaris, from a depth of six fathoms.

The colour of the hepatic cæca in the cerata differed a little in these specimens, being in one much redder and in the others browner. Under a low power of the microscope the colour seems very much yellower than it does to the eye. It is coarsely granular, and in some of the cerata the cæca are much lobed.

Cratena viridis, Forbes.

We found one specimen of this rare species amongst zoophytes dredged from the Turbot-hole near Puffin Island in August, 1889, and took one specimen at Hilbre Island on March 21st, 1890. The latter is the first that has been recorded from the neighbourhood of the Mersey, and the species was only known previously from the other parts of our district by one specimen from the Isle of Man and one from Puffin Island. We also dredged a specimen in Rhoscolyn Bay, Anglesey, during the recent cruise of the "Hyæna" (May, 1890). The following notes were taken from the Hilbre Island specimen in the living condition :—

The length of the body is 4·5 mm. The dorsal and oral tentacles are rather short and colourless, and have slightly irregular edges. There are ten closely placed rows of cerata which are short and stout in form. The hepatic cæca under a low power of the microscope are seen to be irregularly speckled with green and black pigment, while at the apex the cnidophorous sac forms a large opaque yellowish mass. This apical colouring is not superficial as in the case of *Coryphella landsburgi*, *C. rufibranchialis*, and other species, but is apparently in the wall of the sac itself. There is, however, a little opaque white sprinkled down the anterior surfaces of the cerata. One of the larger cerata was found to be bifurcated at its tip, and provided with two distinct cnidophorous sacs. Curiously enough the single specimen from Puffin Island, which we recorded last year, showed exactly the same abnormality.*

The cnidophorous sac (Pl. IX. fig. 12) is flask shaped, and communicates with the hepatic cæcum by a very short tube. Several masses of gland cells (*gl.*) are placed around the junction.

The table on the following page shows the distribution of the species of Nudibranchs recorded up to now in the four regions of our district which have been sufficiently investigated. The first column includes Hilbre Island, while the third takes in the Menai Straits and the coast of Anglesey: we separate Puffin Island from the preceding region merely because it may be convenient for those working at the Biological Station to know what species have been found on the shore. Fifteen species have now been obtained at Puffin Island.

* Proc. Biol. Soc., Liverpool, vol. iii., p. 234.

NUDIBRANCHIATA.	Estuary of the Mersey.	Isle of Man.	North Wales.	Puffin Island.
Archidoris tuberculata	×	×	×	×
A. johnstoni	×	...	...	...
A. flammea	...	×	...	...
Lamellidoris bilamellata	×	...	...	...
L. depressa	×	...	...	...
L. proxima	×	×	...	×
Acanthodoris pilosa	×	...	...	×
A. quadrangulata	×	...	...	...
Goniodoris nodosa	...	×	×	×
G. castanea	...	×	...	...
Triopa claviger	...	×	...	...
Polycera lessoni	×	...	...	...
do., var. *ocellata*	×	...	...	×
P. quadrilineata	...	×	...	...
Ancula cristata	×	×	...	...
Tritonia hombergi	×	×	...	...
T. plebeia	×	...	...	×
Dendronotus arborescens	×	×	×	...
Doto coronata	×	×	...	×
D. fragilis	...	×	...	×
Janus cristatus	×	...	×	...
J. hyalinus	×	...	...	...
Eolidia papillosa	×	×	×	×
Eolidiella glauca	...	...	×	...
Facelina coronata	×	...	...	×
F. drummondi	×	...	×	...
Coryphella lineata	...	×	...	...
C. gracilis	...	...	×	×
C. landsburgi	×	...	...	...
C. rufibranchialis	×	...	...	×
Cratena concinna	×	...	×	...
C. olivacea	×	...	...	...
C. amœna	...	×	...	...
C. aurantiaca	×	...	...	...
C. arenicola	...	...	×	...
C. viridis	×	×	×	×
Cuthona nana	×	...	...	×
Galvina picta	×	×	×	×
G. tricolor	...	×	×	...
Tergipes despecta	×	...	×	...
T. exigua	×	...	×	...
Embletonia pallida	×	...	...	...
Fiona marina	×	...	×	...

Part II. Epipodial Nature of the Cerata.

In a paper* laid by one of us before the British Association last September, it was suggested that all the various projections from the sides and back of Nudibranchs known as cerata are to be regarded as epipodial papillæ, or outgrowths from a more or less distinct epipodial ridge. And Garstang † has independently arrived at the same conclusion in his recent Report upon the Nudibranchs of Plymouth Sound.

Pelseneer has lately drawn attention ‡ to the presence and condition of the epipodia in *Trochus* and other Rhipidoglossate Gastropods, but he does not consider these structures as being homologous with the large epipodial flaps of *Aplysia* and other Opisthobranchs and Pteropods. For these latter he uses the term parapodia, introduced by von Jhering, and open to the objection that it is already appropriated by a totally different structure in another group of animals. But the condition of the parts in *Trochus* is so very similar to that found in *Polycera* and *Idalia*, and the dorso-lateral processes of the two latter forms are so clearly comparable with the large lateral flaps of *Aplysia*, that we are inclined to regard all these projections as being homologous structures, entitled to be considered as epipodial in their nature.

We now give figures of a series of transverse sections (Pl. VI.) for the purpose of showing the condition of the epipodial structures in a number of different forms of Nudibranchs.

The typical epipodia are seen in *Elysia* (Pl. VI. fig. 1)

* Herdman on the Struct. and Functions of the Cerata, &c., Brit. Assoc. Report, 1889 (abstract only), and published in full in Quart. Journ. Microsc. Science, vol. xxxi., p. 41.

† Journ. Mar. Biol. Assoc., vol. i. no. 2., p. 181.

‡ Sur l' épipodium des Mollusques, Bull. Sci., 1888, p. 182.

or in *Aplysia* (fig. 2,) in a well developed state, and a transverse section through the latter mollusc at about the junction of the anterior and middle thirds of the body shows that the epipodia are folds of the lateral integument, extending upwards and inwards (Pl. VI. fig. 3, *e.p.*) so as to cover over the greater part of the dorsal surface.

It is generally believed * that the fold of integument over-hanging the foot in *Doris* should be regarded not as a mantle edge but as an epipodial ridge. Figures 4 and 5 show transverse sections through *Doris pilosa*, and the lateral ridges (*e.p.*) above the foot are seen to be large, to have the same general relations as the epipodial folds of *Aplysia*, and to bear on their surface a number of prominent papillæ. When we examine next a transverse section of *Goniodoris nodosa* (Pl. VI. fig. 6) we find that the lateral ridges have assumed a more dorsal position, and have slightly projecting nodules or papillæ at intervals along their course. In *Polycera* (Pl. VI. figs. 7, 8, 9) we find the same lateral ridge has become more prominent, bears more distinct papillæ throughout its course, and rises up at its posterior end alongside the median dorsal branchiæ to form a pair or more of large simple or bifurcating processes which are entitled to the name of cerata (Pl. VI. fig. 9).†

In the genus *Idalia* a similar epipodial ridge is present bearing numerous slender cerata, especially in its posterior part, alongside the branchiæ; and even in *Ægirus punctilucens*, where the back and sides of the body bear numerous tubercles, there is a row of larger projections distinctly visible on each side, which probably represents the epipodial ridge of other forms (Pl. VI. fig. 11, *e.p.*).

* E.g., see Lankester, Ency. Brit., 9th ed., vol. xvi., Art. Mollusca, p. 655.

† Parieto-cerata, Herdman, loc. cit.. Quart. Jour. Mic. Sc., p. 42.

In *Ancula cristata* the lateral ridge has almost disappeared as a ridge, but it is evident that the five pairs of large simple cerata placed at the sides of the branchiæ (fig. 10) correspond to the similar structures seen in *Polycera* and *Idalia*. Then in *Triopa claviger* (fig. 12) the cerata have become more numerous (seven pairs), are directed more laterally, and extend from the head nearly to the posterior end of the body.

In passing next to the family Tritoniidæ we find that the cerata become branched in an arborescent manner, but on comparing sections of *Goniodoris* (fig. 6) or *Polycera* (fig. 9) with those of *Candiella plebeia* (fig. 13) it is impossible to doubt that one is dealing with the same series of projections. *Cabrilla occidentalis*, which has been lately described and figured by Fewkes,* presents an interesting intermediate condition between *Triopa* and *Tritonia*. *Cabrilla* is evidently referable to the Doridæ ; it has short laminated rhinophores and a posteriorly-placed circle of branchiæ, but is possessed of six or seven pairs of laterally-placed cerata which are branched at their ends, and are evidently comparable with the parieto-cerata of *Tritonia* and *Dendronotus*. In *Dendronotus* the large parieto-cerata become very complicated in form (fig. 14), but are evidently merely a further development of the smaller but similar processes of *Candiella* or *Tritonia*.

Finally, in the great group Cladohepatica we find large and conspicuous hepato-cerata (Pl. VI. figs 15 and 16), as in *Doto*, *Eolis*, and *Proctonotus*, but we must regard these as being merely cerata, originally like those of the Doridæ and Tritoniidæ, which have been invaded by the hepatic cæca and have afterwards become enlarged and modified

* Zoological Excursions, I. New Invertebrata from California : Boston, 89, p. 44.

in various ways. In *Doto* (fig. 15) there is a single row of cerata on each side of the body, but each member of the row is lobed. In most species of *Eolis* (fig. 16) there are several rows of cerata on each side, or in other words each of the lobed cerata of *Doto* is represented by a group of simple cerata in *Eolis* (see Pl. VI. figs. 15 and 16).

Consequently we think there are grounds for considering all these dorso-lateral projections, whether they be ridges or parieto-cerata or hepato-cerata, simple or branched, as being epipodial in their nature.

Part III. Experiments with Fishes.

With the view of testing the theory that the remarkable shapes and colours of Nudibranchs are either of a protective or of a warning nature,* and are definitely related to their edibility or the reverse, we arranged some experiments on the feeding of Fishes with Nudibranchs, which were carried out in the Aquarium of the Liverpool Free Public Museum, with the kind co-operation of the Curator, Mr. T. J. Moore, and some of his assistants.

Most of the experiments were made in three large fish tanks, which may be called A, B, and C. A and B are rectangular slate and plate-glass wall-tanks lit from the top, measuring 7½ feet long, 5¼ feet wide, and 3¼ feet high, and containing each about 700 gallons of sea water and some rock-work. A has a gravel bottom, and contains about twenty very healthy and active adult shannies (*Blennius pholis*, obtained from the Menai Straits); while B has a sandy floor and is devoted to flat fish—it contains a considerable number of soles (*Solea vulgaris*) and plaice

* See Herdman, Opening Address, in Trans. Biol. Soc., Liverpool, vol. iv., p. 16; and Quart. Journ. Microsc. Sci., vol. xxxi., p. 41, April, 1890.

(*Pleuronectes platessa*), a few small thornback rays (*Raia clavata*), turbot (*Rhombus maximus*), and one brill (*Rhombus lævis*), and on one occasion had some young cod (*Gadus morrhua*). The average size of these flat fish is six or seven inches in length, and there are over sixty of them altogether in the tank.

C is an octagonal centre or table tank with a sandy bottom, measuring 4 feet 6 inches in diameter and 17 inches in depth, and holding about 100 gallons of water. It contains various small fishes, viz., bullhead (*Cottus bubalis*), wrasse or goldsinny (*Ctenolabrus rupestris*), pogge (*Agonus cataphractus*), gemmeous dragonet (*Callionymus lyra*), five-bearded rockling (*Motella mustela*), viper weever (*Trachinus vipera*), and young cod (*Gadus morrhua*).

All these fishes were in a thoroughly healthy condition, and some of them had been living undisturbed in their tanks for periods varying up to four years. The water in the tanks is kept aerated, and in constant circulation by a water engine. The fish are usually fed upon mussels, cockles, and occasionally worms, which are thrown in at the top of the tank and allowed to sink slowly through the water. Such food matters are usually seen at once and eagerly pounced upon and eaten during their descent. We adopted the same plan in putting most of the nudibranchs into the tanks; and as, in anticipation of the visit to the Aquarium in the afternoon, the fishes were not fed on the days we intended to experiment with them, they had been fasting for about twenty-four hours, and so may be regarded as being unusually eager to seize any object dropped into the water. At the beginning, and again at the end of each day's experiments, we threw a couple of cockles or mussels into the tank, and found that they were at once caught and bolted in the usual manner.

I. October 29th, 1889. [A supply of healthy average-sized specimens of *Lamellidoris bilamellata* was obtained from the rocks at New Brighton. Mr. Moore, the curator; Mr. R. Paden, assistant; and Woods, the Aquarium attendant, were present. Notes were taken by Professor Herdman.]

A. Shanny Tank:—

*Doris** 1.—Seized when falling by a fish and taken at once to dark corner.

2.—Seized and at once rejected; seized by another fish and at once rejected; seized by a third and rejected, then allowed to lie on bottom.

3.—Seized and rejected by two fish in rapid succession, then seized by third and taken to dark corner.

4.—Seized and rejected by first fish, taken to dark corner by second.

5.—Seized and rejected by three fish in rapid succession, and then left.

B. Flat Fish Tank:—

Doris 1.—Seized and rejected in rapid succession by a turbot, a sole, another sole, and a plaice, and then left lying on sand.

C. Table Tank:—

Doris 1.—Seized and rejected by a wrasse, tried again by same and again rejected, then left.

2.—Seized and rejected by a *Cottus* and by a dragonet in rapid succession and then left.

* In the account of these experiments we shall use the old well-known generic names *Doris* and *Eolis* instead of *Lamellidoris*, *Coryphella*, &c.

Finally, another *Doris* was dropped gently into a fourth tank containing a conger eel so as to fall in front of its nose, but although the fish passed close to the nudibranch several times while under observation it apparently took no notice of it, and certainly made no attempt to seize it.

From these nine experiments there can be but little doubt that *Doris bilamellata* is distasteful to these eight kinds of fish. This was an unexpected result, as the *Doris* has no stinging apparatus, and certainly seems to be protectively coloured. The distastefulness may be due either to the spicules in the skin or to the abundant mucus covering the body.

II. February 21st, 1890. [We brought a large supply of *Ancula cristata*, and a few specimens of *Dendronotus arborescens*, *Coryphella rufibranchialis*, and *Galvina picta*, which we had collected at Hilbre Island the previous evening. Mr. Moore, Mr. R. Paden, and Woods were present. Notes were taken by Professor Herdman.]

Mr. Moore and Professor Herdman each eat an *Ancula*. The specimen was placed alive upon the tongue. No stinging or other disagreeable sensation was perceived. It was then chewed slowly and swallowed. The taste was pleasant, and distinctly like that of an oyster.

Ancula cristata.

A. Shanny Tank :—

Ancula 1.—Seized and rejected by a fish and then bolted suddenly by a second.

2.—Seized when falling and rejected by ten fish in rapid succession.

3.—Seized when falling and swallowed by a fish.

4.—Seized and rapidly rejected by five fish in succession.

5.—Seized and rapidly rejected by four fish in succession.

B. Flat Fish Tank :—

Ancula 1.—Seized and rejected by a young cod and six plaice in rapid succession.

2.—Seized and rejected by seven plaice in rapid succession and left lying on sand.

3.—Seized and rejected by four plaice in rapid succession and left lying on sand.

The fish were then tried with some cockles, which, when thrown in, were eagerly pounced upon and eaten. Then four specimens of *Ancula* were thrown in together and were tried and rejected by two young cod and three plaice.

C. Table Tank :—

Ancula 1.—Touched by a young cod but not taken, then tried and rejected by goldsinny.

2.—Touched and rejected several times by cod.

3.—Touched and rejected by first cod, bolted suddenly by second.

The shannies at once take an object into the mouth even though they reject it again immediately, but the young cod usually approach it very closely and appear to smell it or feel it with the lips and then turn away from it, or else suddenly bolt it, in which case it does not reappear. The shanny seems to test the edibility inside its mouth, the cod outside.

Some crabs (*Hyas araneus*) in two small tanks were then tried with specimens of *Ancula* with the following results :—

Ancula 1.—Seized at once by crab but eaten very slowly. Pulled to pieces by third maxillipedes, and apparently only some parts eaten.

2.—Taken no notice of.

3.—Taken up by chela, then dropped and left.

4.—Apparently not noticed by crabs.

The three last specimens of *Ancula* were found alive and fully expanded next day, and crawled about the two crab tanks undisturbed for some time.

Finally a few specimens of *Ancula* were taken to the anemone tank and allowed to drop upon the fully expanded tentacles of a white and a pink *Actinoloba dianthus;* they were not swallowed in either case, but after lying for some time were allowed to fall off the tentacles.

In all, then, *Ancula* was rejected by fifty-three animals and taken by four. These experiments gave us the distinct impression that *Ancula* was distasteful to the animals tried, although we did not at that time understand why and had expected to get a contrary result.

Dendronotus arborescens.

A. Shanny Tank:—

Dendronotus 1.—Seized at once by shanny and carried off to back of tank. Shortly afterwards two shannies were found fighting over it, each having hold of an end, as they do with a large worm, finally they each ate a part of the *Dendronotus*.

B. Flat Fish Tank:—

Dendronotus 1.—Tried and rejected by brill and young cod. Then seized by plaice and kept in mouth for a long time, during which it was pursued by other fish.

C. Table Tank:—

Dendronotus 1.—Touched and left by a young cod, taken partly into mouth and rejected by two bullheads (*Cottus*) four or five times.

The general impression we received was that *Dendronotus* was more acceptable to the fish than *Ancula*, but that they were incommoded by the size. Our specimens were large ones, over two inches in length, and none of the fishes tried seemed able to get the whole of the *Dendronotus* comfortably into the mouth at once; several took half the body into the mouth and swam about with the other half hanging out. This was well seen in the case of the shannies who each eat half of the specimen, and of the plaice which carried about its prey for a considerable time, during which it was actively pursued by the others. That specimen was in all probability eaten by one or more of the plaice, as we could find no trace of it some little time afterwards. The rejection by *Cottus* may be accounted for by the awkward size of the morsel. The two fish had each at least two tries at it, taking it half into the mouth, giving it a shake, sending it out, and then going at it again as if to get a better hold.

Eolis.

A. Shanny Tank:—

Eolis 1.—(*Coryphella rufibranchialis*)—Seized by largest shanny, who at once shook it vigorously and kept moving its jaws and ejecting the cerata in groups of three or four, and finally put out the rest of the body. Then tried and rejected by four or five other fish in rapid succession, and then by the large shanny again, then by several others, and finally left lying at the bottom of the tank. The large shanny who first tried it was noticed going about for some time afterwards (5 p.m.) with the mouth held open, but was all right again next morning.

C. Table Tank :—

Eolis 2.—(*Galvina picta*)—Touched or tried and rejected at once by cod, bullhead, and weever. The cod came very near it or touched it with its snout several times afterwards, but never took it into the mouth.

Eolis is undoubtedly distasteful. The cnida on the tips of the cerata probably sting the lips, &c., of the fish.

As it had occurred to us that the natural conditions would be more nearly reproduced if the nudibranchs were not dropped into the tank, on the following day, February 22nd, a few specimens of *Ancula* were placed upon pieces of stone and lowered cautiously into tanks A and B in such a way as not to attract the attention of the fish. The nudibranchs reached the rockwork safely, and were seen crawling over various parts of the tanks for several days untouched by the fish (shannies and flat fish). Woods (the Aquarium attendant) tells us that the fish sometimes went close to the *Ancula* and looked at them but never attempted to touch them. The nudibranchs were last seen about a week after being put into the tanks. They then disappeared, but may possibly have retreated into the back part of the tank, or have crawled up out of the water as *Ancula* is very liable to do when kept in captivity.

III. March 22nd, 1890. [We brought to the Aquarium specimens of *Dendronotus*, *Eolis*, and *Doris*, which we had collected at Hilbre Island on the previous afternoon. Mr. Moore, Mr. Chard, assistant, and Woods were present—Professor Herdman taking notes.]

Dendronotus arborescens.

A. Shanny Tank :—

Dendronotus 1.—Seized at once by the large shanny and kept in mouth, half the nudibranch projecting. This shanny was pursued by others, one of which caught the projecting end of the prey, and in the ensuing struggle tore half the body off and eat it. The large shanny at once retreated with the remainder to the back of the tank; came out shortly afterwards with the *Dendronotus* still in mouth, and was again pursued and retreated to the back, appearing again soon without the nudibranch.

C. Table Tank :—

Dendronotus 1.—Pounced upon at once by three bullheads which made rapid dabs at it successively, until one secured it and carried it off to a quiet place where he seized it in his mouth and rejected it nine times in succession, each time taking it half into the mouth and keeping it there for some seconds, then spitting it out and at once pouncing upon it again. Finally the now somewhat mangled remains of the *Dendronotus* were taken out and put into tank A, where one of the shannies at once seized and swallowed it. The *Dendronotus* was large. It was larger than the head of the *Cottus*, and caused the mouth cavity to bulge out greatly when half taken in. The general impression was that the *Cottus* found the *Dendronotus* desirable food but an uncomfortably large mouthful and was trying to worry it to pieces.

Eolis.

A. Shanny Tank :—

Eolis 1.—(*Coryphella rufibranchialis*).—Tried and at once rejected by three fish in rapid succession, then seized by the large shanny and carried behind the rock-work; immediately numerous red cerata were seen scattered through the water in that neighbourhood, showing that the *Eolis* had been forcibly ejected in pieces. The cerata floated about for some time in the water, but were not touched by any of the fish.

2.—(*Facelina coronata*).—Pounced upon by several fish together—one secured it and at once rejected it, and then seized the white body and managed to bite it across, setting free the dorsal portion with all the cerata. It then retired to the back of the tank, and the cerata were left floating about in the water untouched.

Doris bilamellata.

A. Shanny Tank :—

Doris 1.—Tried and rejected by two fish, then seized by large shanny and carried off to back of tank.

B. Flat fish Tank :—

Doris 2.—Several fish darted at the nudibranch, but a large sole suddenly slipped up vertically between them and bolted it.

3.—Tried and rejected by six or eight plaice, and finally left on the sand.

4 to 6.—These three specimens were gently lowered into the tank by a net, so as to reach a shelf of the rock-work without attracting attention. They soon began to expand and move. One plaice

swam up and looked or smelled at them but did not touch them.

The action of the large sole in bolting *Doris* No. 2 above may possibly be explained as a result of the habits of competition for their food. Three or four other fish were darting at the nudibranch and the sole took the only possible course by which it could secure the prey; it made a rapid movement upwards between the snouts of its competitors and swallowed the *Doris* entire; there was evidently no time for examination.

These experiments are manifestly incomplete and must be largely added to in the future, but we believe it may be useful to publish them at this stage, especially as we would be glad of suggestions from any other biologists working on the same lines.* Our general impression is that the order of edibility of the nudibranchs offered to the fishes is:—*Dendronotus*, *Doris*, *Ancula*, and *Eolis*: *Eolis* being the most distasteful form, *Ancula* next, *Doris* less so, and *Dendronotus* edible, but from its size offering difficulties to the rather small fishes which we tried.

We have used altogether fifty-three nudibranchs, offered to twelve different kinds of fish and other voracious animals, and we have recorded over a hundred and thirty distinct transactions between the fishes and the nudi-

* Mr. Bateson's interesting paper on "The Sense-organs and Perceptions of Fishes," in the last number of the Jour. Mar. Biol. Assoc., dated April, 1890, which however only reached Liverpool on May 14th, has appeared since our paper was read (May 9th) and just as we are passing it for press. In regard to the sole being one of those fishes which hunt for their food and recognise it by the sense of smell alone, we would remark that the specimens in the Aquarium here certainly seem to perceive their food as the plaice do by sight, the two kinds of fish often darting together at a food morsel—and, as has just been shown above, the sole being sometimes more alert than its competitors. Possibly these soles have changed their habits like the rockling described (p. 238) by Mr. Bateson.

branchs. Our nudibranchs were all alive, healthy, and good-sized specimens; and our fish were probably the right kind, being nearly all shore fishes, found in the immediate neighbourhood of where the nudibranchs live. But still the conditions were, of course, to a certain extent artificial, and that must be taken into account in drawing conclusions. Dropping the nudibranchs into the tank from above is unnatural, and may give rise to a misleading result, especially where the fish are accustomed to have their food thrown in from above, and *only receive edible food.*

Then again, at least some of the fish—those that have been some time in captivity, have been educated to compete with one another for the food masses. When *anything* is thrown in—a bit of white shell will do—there is at once a rush made upon the falling object, and no time is allowed for inspection or consideration. I would account for the seizing of *Eolis* by the shannies (very active, voracious, and apparently impulsive fishes), even when the prey is evidently distasteful and has brilliant warning colours, as a result of this acquired habit of competition, and of pouncing upon anything thrown into the tank; several times when a morsel was suddenly bolted, it seemed to be because another fish was coming up to seize it. Still there is a marked difference between the manner in which they take a cockle and, say, an *Ancula*. The cockle is taken right in and swallowed at once, while the distasteful nudibranch, even if seized, is usually only partly taken into the mouth, in some cases it is seen to be held by the very front of the jaws, and is then ejected with force.

Ancula has been a particularly interesting case. Starting with the general opinion that *Ancula* is a perfectly defenceless soft-bodied animal, we were astonished to find that it was present on the rocks at Hilbre Island in great abundance, in very prominent and exposed situations, and that its colouring was not protective but rendered it conspicuous. Our experiments at the Aquarium next showed us that this nudibranch is distasteful to fishes and other shore animals, but for a time we did not understand why. Lately, however, we have found that besides the abundant mucous glands scattered over the integument, *Ancula* possesses special large glands,* occupying the apices of the cerata and opening on the exterior. These glands are placed just where an offensive organ would be most useful, and where the stinging cells are found in *Eolis*, and it seems probable that their secretion has an acrid or some other objectionable property.

The protective colouring of *Doris bilamellata* † may be accounted for in one or both of two ways:—(*a*.) It may serve to protect from certain other shore animals which we have not yet tried, and to which the spicules and mucus of the *Doris* are not objectionable, and (*b*) it may save the animal from being tried by fishes, &c., not sufficiently aware of its (to them) distasteful nature.‡ It is obvious that if an animal is not thoroughly objectionable, and has not yet become conspicuous with warning colours, it will be better for it to be protectively coloured. *Eolis* is a most distasteful form and has conspicuous colours of a warning

* See this Report, p. 135 and Pl. vii. fig. 9, *gl*′.

† See this Report, p. 133.

‡ A very similar case seems to be that of the two British species of *Hermœa* as described by Garstang (loc. cit., p. 191). *H. bifida* has its conspicuous hepatic ramifications exceedingly like the branches of the red seaweeds of the genus *Griffithsia* amongst which the animal lives. *H. dendritica* is coloured bright green so as to resemble *Codium tormentosum* on which it lives. Both species are protectively coloured and have no stinging cells like those of *Eolis*, but they seem to possess the power of emitting, when irritated, an offensive fluid.

nature. *Ancula* is also distasteful and is conspicuously coloured. *Doris* is less distasteful and is still protectively coloured; while *Dendronotus*, which we believe to be edible, is very effectually concealed amongst the seaweeds it lives on by its large branched cerata and red-brown colours.

Explanation of the Plates.

Where not otherwise stated, the drawings were made from serial sections prepared by hardening in Kleinenberg's picric acid and graduated alcohols, staining in picrocarmine, embedding in paraffin and cutting with the rocking microtome.

Reference Letters.

ap. opening of cnidophorous sac to exterior; *br.* branchiæ; *b.s.* blood sinus; *c.* cnida; *c.c.* cnidocysts; *c.s.* cnidophorous sac; *c.d.* connecting duct between cnidophorous sac and hepatic cæcum; *cer.* cerata; *d.* duct of gland; *e.p.* epipodial ridges, folds, or processes; *ec.* ectoderm; *f.* foot; *f.gl.* foot glands; *g.c.* goblet-like mucus-secreting cell; *gl, gl'* glands; *h.c.* hepatic cæcum; *k.* knob on papillæ of cerata of *Doto*; *l.l.* lateral duct of liver leading from hepatic cæca; *m.* mantle; *m.p.* metapodium; *mes.* mesodermal tissue; *m.f.* muscle fibres; *m.l.* median duct of liver in body; *o.t.* ovotcstis; *p.p.* propodium; *pg.* pigment; *rh.* rhinophores; *r.* red pigment; *t.* tentacles; *y.* yellow pigment.

S. 1. =	Swift's 1 in. obj.,	oc. 2,	magnifying	about		45	diam.
S. $\frac{1}{4}$. =	,, $\frac{1}{4}$	,,	,,	,,	,,	230	,,
S. $\frac{1}{6}$. =	,, $\frac{1}{6}$	,,	,,	,,	,,	330	,,
Z. $\frac{1}{12}$. =	Zeiss's $\frac{1}{12}$ (oil immers.),	oc. 2,	,,	,,		505	,,

Plate VI.

Comparative views of the condition of the Epipodia as seen in transverse sections of various Opisthobranchiate Mollusca.

Fig. 1. Sketch of *Elysia* from the dorsal surface to show the epipodia (*e.p.*) × 2.

Fig. 2. Sketch of *Aplysia* from the left side to show the epipodia (*e.p.*), nat. size.

Fig. 3. Outline of transverse section of *Aplysia*, one-third along the body from the front, to show the relations of the epipodia (*e.p.*), mantle (*m*) and foot (*f*). Zeiss a*, 10.

Fig. 4. T.S. (transverse section) of *Acanthodoris pilosa*, through the rhinophores (*rh.*) showing the epipodial ridge and large papillæ. S.1. reduced.

Fig. 5. Another section of the same, about middle of body, showing the distinctly lateral arrangement of the papillæ. S.1. reduced.

Fig. 6. T.S. of *Goniodoris nodosa*, one-third along body from the front (ten sections behind rhinophores), to show the lateral epipodial ridges (*e.p.*). S.1.

Fig. 7. T.S. of *Polycera quadrilineata* (60th sect. from front) showing the lateral ridges at the sides of the rhinophores. S.1. Compare with fig. 4.

Fig. 8. Another of same (150th sect. from front, about middle of body) showing the prominent ridges (right side) and processes (left side) containing glands, placed at the sides of the branchiæ. S.1.

Fig. 9. Another of same (60th sect. from posterior end, about three-fourths along body) showing the large epipodial processes (or "cerata") containing glands. S.1.

Fig. 10. T.S. of *Ancula cristata*, showing the large cerata (*e.p.*) alongside the branchiæ (*br.*) S.1. Compare with fig. 8.

Fig. 11. T.S. of *Ægirus punctilucens*, showing the row of large lateral papillæ (*e.p.*) representing the epipodia. S.1.

Fig. 12. T.S. of *Triopa claviger*, showing the lateral cerata and dorsal papillæ. S.1. Compare with fig. 11.

Fig. 13. T.S. of *Tritonia plebeia*, about middle, showing the branched cerata. S. 1.

Fig. 14. T.S. of *Dendronotus arborescens*, about middle, showing the large branched parieto-cerata, S. 1., reduced.

Fig. 15. T.S. of *Doto coronata*, about middle, showing the large lobed hepato-cerata. S. 1.

Fig. 16. T.S. of *Eolis*, showing the clumps of simple hepato-cerata representing epipodia. S.1.

Plate VII.

Figs. 1 and 2. *Aplysia punctata.*
Figs. 3 and 4. *Polycera quadrilineata.*
Figs. 5 to 9. *Ancula cristata.*

Fig. 1. Section of the edge of the epipodium of *Aplysia punctata* to show the glands (*gl.*). S. ¼.

Fig. 2. Section of the mantle edge of *Aplysia* to show the very numerous large glands opening on the lower surface (*gl.*) S. ¼.

Fig. 3. Vertical section of one of the cerata at the posterior end of the epipodial ridge of *Polycera*

quadrilineata, to show the abundance of glands (*gl.*). S. 1.

Fig. 4. Small piece of edge of same more highly magnified to show the structure of the glands (*gl.*). S. $\frac{1}{6}$.

Fig. 5. Transverse section through *Ancula cristata*, near posterior end of body, to show the foot glands (*f. gl.*) and the special lateral glands (*gl'.*). S. 1.

Fig. 6. Part of edge of foot of same more highly magnified to show the structure of the glands. S. $\frac{1}{6}$.

Fig. 7. Transverse section of one of the cerata of *Ancula*, showing the ceratal blood sinus (*b.s.*) and the glands (*gl'.*). S. 1.

Fig. 8. Longitudinal section of one of the cerata of *Ancula*, showing the ceratal blood sinus (*b.s.*) and the glands (*gl'.*). S. 1.

Fig. 9. Part of the edge of same near tip, showing the structure of the glands (*gl'.*). S. $\frac{1}{6}$.

Plate VIII.

Figs. 1 to 6. *Coryphella rufibranchialis.*
Figs. 7 to 10. *Coryphella landsburgi.*

Fig. 1. Tip of one of the cerata of *C. rufibranchialis*, drawn from the living specimen, showing the very broad superficial zone of opaque white pigment (*pg.*) which covers the greater part of the cnidophorous sac (*c.s.*). S. 1.

Fig. 2. Five cnida of *C. rufibranchialis*, discharged from living specimen. S. $\frac{1}{6}$.

Fig. 3. Part of a longitudinal section (not quite median) of cerata of *C. rufibranchialis*, showing the lobulated condition of the hepatic cæcum (*h.c.*) S. 1.

Fig. 4. Longitudinal section of apex of cerata of *C. rufibranchialis*, showing the cnidophorous sac (*c.s.*)

and its connection with the hepatic cæcum (*h.c.*) S. $\frac{1}{4}$.

Fig. 5. Part of the edge of one of the cerata of *C. rufibranchialis*, drawn from the living specimen, slightly squeezed, to show the colours of the hepatic cæcum. *y.* indicates the generally distributed yellow granules, *r.* the masses of red pigment, and *cl.* the groups of clear globules. S. $\frac{1}{4}$.

Fig. 6. The contents of the hepatic cæcum when squeezed out of the living specimen: *a*, vesicle containing yellow granules; *b*, vesicle containing red granules; *c*, clear oil-like globules. Z. $\frac{1}{12}$.

Fig. 7. Tip of one of the cerata of *C. landsburgi*, drawn from the living specimen, showing the superficial zone of opaque white pigment (*pg.*) surrounding the middle of the cnidophorous sac (*c.s.*). S. 1.,

Fig. 8. Apex of cnidophorous sac of *C. landsburgi*, slightly squeezed while alive and emitting cnida (*c.*) S. $\frac{1}{6}$.

Fig. 9. Group of cnida of *C. landsburgi*. S. $\frac{1}{6}$ (the two lower ones enlarged, Z. $\frac{1}{12}$).

Fig. 10. The subepithelial layer of the integument in surface view; drawn from the living specimen, showing the violet-coloured pigment corpuscles (*pg.*) to which the colour of the body is due. S. $\frac{1}{6}$.

Plate IX.

Figs. 1 to 4. *Doto coronata.*
Figs. 5 to 7. *Facelina coronata.*
Figs. 8 to 10. *Facelina drummondi.*
Fig. 11. *Galvina picta.*
Fig. 12. *Cratena viridis.*

Fig. 1. Transverse section of *Doto coronata*, near the

middle, to show the relations of the hepatic cæca to the body and to the large turretted cerata (*cer.*). S. 1.

Fig. 2. Section through one of the papillæ on the cerata showing the small terminal knob (*k.*) and the masses of gland cells (*gl.*). S. $\frac{1}{8}$.

Fig. 3. Section through the edge of one of the cerata showing the large masses of gland cells lying between the hepatic cæcum (*h.c.*) and the epithelium (*ec.*). S. $\frac{1}{8}$.

Fig. 4. Section through one of the papillæ on the cerata showing a cavity and duct (*d.*) amongst the gland cells and leading to the apex of the knob (*k.*) S. $\frac{1}{8}$.

Fig. 5. Section through the base of one of the cerata of *Facelina coronata*, showing the opening of the hepatic cæcum into one of the lateral ducts of the liver (*l.l.*). S. 1.

Fig. 6. Transverse section through the tip of one of the cerata of *F. coronata*, showing the hepatic cæcum (*h.c.*), cnidophorous sac (*c.s.*) and connecting tube (*c.d.*) all cut transversely. S. $\frac{1}{8}$.

Fig. 7. Some of the long curved cnida of *F. coronata*, S. $\frac{1}{8}$. enlarged.

Fig. 8. Upper half of one of the cerata of *F. drummondi*, mounted entire, showing the long connecting tube (*c.d.*) between the cnidophorous sac and the hepatic cæcum. S. 1, reduced.

Fig. 9. Part of edge of one of cerata of *F. drummondi*, from living specimen, showing the cilia on the surface and the colours of the hepatic cæcum. S. $\frac{1}{8}$. *r*, red; *y*, yellow.

Fig. 10. A few of the yellow (*a*) and red (*b*) cells squeezed out of the last when alive. Z. $\frac{1}{12}$

Fig. 11. Transverse section through tip of one of cerata of *Galvina picta*, showing the cnidophorous sac (*c.s.*) S. $\frac{1}{6}$.

Fig. 12. Apex of one of the cerata of *Cratena viridis*, mounted entire and seen in optical section, showing the opening (*ap.*) of the cnidophorous sac (*c.s.*) to the exterior, and the clumps of gland cells (*gl.*). S. $\frac{1}{6}$.

The POST-EMBRYONIC DEVELOPMENT of a GNAT (CULEX).

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With Plate V.

[Read January 10th, 1890.]

The eggs of the gnat are laid side by side, and cemented together forming a raft, and as the eggs are thicker below than above this raft is convex below and concave above. It is to be found floating on the surface of still water, especially in early spring. Each egg has at its lower end, *i.e.*, under water, an aperture closed by a lid which opens to allow the escape of the larva. The larva is an active free-swimming worm-like creature with powerful jaws, by means of which it feeds chiefly upon minute algæ and on decaying leaves. The head has on each side a small compound eye, and behind this a simple eye. A very short thin neck attaches the head movably to the broad thorax, the latter consisting of three ill-defined segments. The abdomen is long and comparatively slender, and consists of nine obvious segments, the last one being bent downwards at an angle and bearing a median row of setæ below which serves as a propeller. At its extremity is the anus, surrounded by four small leaf-like gills. From the dorsal surface of the abdomen, at the hinder end of its eighth segment, a conspicuous respiratory siphon projects upwards and backwards. This is about equal in length to three segments of the abdomen, and the aperture at its end is provided with a valvular apparatus, by means of which it is closed except when at the surface of the water it is opened to allow the animal to take a fresh supply of air into its enormous tracheæ.

The alimentary canal is nearly straight. The mouth cavity receives the secretion of a pair of salivary glands by a median aperature. The narrow œsophagus opens into the "stomach" at the anterior end of the thorax. The stomach is wide and extends to the sixth abdominal segment. In the thorax it has eight large sac-like diverticula. The epithelial cells lining the stomach and its diverticula are extraordinarily large. The short ileum runs from the hinder end of the stomach to the wide anterior end of the rectum at the beginning of the eighth segment. It receives five malpighian cæca at its anterior end, the odd one being dorsal. The rectum is wide in the eighth segment, narrower in the last segment, and is stated by Raschke (4) * to be respiratory. The nervous system has the typical arrangement—supra-œsophageal ganglia with optic lobes on their outer sides—subœsophageal ganglia and a ventral cord with ganglia in each of the three segments of the thorax and each of the first eight segments of the abdomen.

The larva at first feeds actively and grows rapidly. Towards the end of larval life it becomes sluggish, and floats with the tip of its siphon at the surface of the water. It no longer feeds, for changes preparing it for the future state have rendered its jaws useless. Shortly the cuticle splits along the mid-dorsal line of the thorax. A pair of hollow, horn-like organs, the respiratory siphons of the pupa are protruded; the tracheæ of the abdomen appear to collapse and the animal floats anterior end uppermost, while the pupa gradually makes its way out of the last larval cuticle.

The exuviæ consist of the cuticular covering of the

* The numbers in brackets refer to the list of works at the end of the paper.

whole larva, with its hairs and jaws, together with the lining ("intima") of the main tracheal trunks—this last is drawn out of the escaping pupa in a series of fragments, one pair being drawn out through the hinder thoracic stigmata, one pair through the stigmata of each of the first seven segments of the abdomen, and the hindermost through the larval respiratory siphon, the soft parts of which are withdrawn and introverted into the eighth segment of the pupal abdomen. The pupa is about 9 mm. long, and consists of head, thorax, and abdomen. The head and thorax together form a rounded mass somewhat compressed from side to side, the head with its appendages bent backwards below the thorax, the large wings extending downwards and backwards and making the thorax appear larger than it really is. The abdomen is slender and dorsoventrally compressed. It alone is obviously segmented* and is highly flexible in the dorsoventral plane, but not from side to side. Its eighth segment bears a pair of large oval plates which serve as a propeller.

The pupa does not feed. It breathes air directly by means of its two prothoracic siphons. It has no tracheal-gills. The position of its appendages will be easily understood from figures 1 and 2 (Pl. V.). The internal structure of the young pupa is of course essentially the same as that of the advanced larva.

The pupa floats quietly at the surface of the water in the position shown in figure 1, except when disturbed, but a gentle tap on the side of the aquarium, a sudden loud noise, or other disturbance of the surface of the water, or the sudden fall of a shadow or of a bright light upon the pupa itself, causes it to dart downwards and backwards by powerful flexion of the abdomen.

* In speaking of the pupa I shall use the names first, second, etc., segments to signify first, second, etc., segment of the abdomen.

The mid-dorsal region of the anterior portion of the thorax is transversely corrugated, and about the end of the fourth day of pupa life the cuticle splits longitudinally in this region and the imago escapes—first the thorax then the head and its appendages, then the wings and legs, and lastly the abdomen. After resting a moment on the empty pupal cuticle and on the surface of the water it flies away.

The imago hardly needs to be described, though fortunately it is a comparatively rare animal in Liverpool. In form it closely resembles *Tipula* (the crane fly or daddy-long-legs), but differs from that fly in possessing a very large proboscis, by means of which the female, at any rate, pierces the skin and sucks the blood of man.

The proboscis consists of a labrum-epipharynx, a pair of mandibles, a pair of maxillæ with their palps, a hypopharynx or "tongue" (lingua), and a labium or "lower lip," with the labellæ. The labrum-epipharynx is an imperfect tube, being open along its posterior surface. The hypopharynx is a long slender plate, which, during the sucking operation, is applied to the hinder surface of the labrum-epipharynx, so as to close the slit in its posterior surface. The anterior surface has a median grove for the transmission of saliva into the wound, this, presumably, serving to liquefy the blood. The hypopharynx of the male is continuous with the labium.

The mandibles and maxillæ are long slender stylets, the maxillæ of the female being saw-like near the tips. Their palps are attached near the base, and are clothed with hairs which are, in the male, very large. The labium, the hindmost of these mouth-parts, forms a sheath enclosing all the other parts except the palps. It is clothed with scales like those of a moth, and bears at the tip two small lobes, the labellæ. The labium represents a second pair of maxillæ, and the labellæ their palps.

The antennæ are very large in the male and bear large hairs—in the female they are smaller and provided only with few hairs. The basal joint of each is very large and hemispherical—I shall call it the *ear*, and my reasons for doing so will appear later. The compound eyes are very large, especially in the male, and cover almost the whole surface of the head. The ocelli are small and black and abut upon the *hinder* margins of the compound eyes, a position which has led to their being overlooked. One pair is present. The neck is very short and slender, giving the head very free movability, the body and legs are covered with scales varying in colour in different species, and similar scales are found on the "veins" of the wings.

The hinder end of the abdomen of the male has a large pair of "outer gonapophyses," forming a pair of forceps, by means of which he grasps the female during copulation. These appear to be serially homologous with the thoracic legs, and are appendages of the ninth segment of the abdomen. Smaller appendages, also accessory genital organs, appear to be appendages of a tenth and perhaps also of an eleventh segment, but these segments are even more difficult to identify than in the cockroach. The "cloaca" said to be found in the females of allied genera is not present—the anus and the genital aperture are quite distinct.

The imago breathes by stigmata at the sides of the body, two pairs thoracic and one pair in each of the first seven segments of the abdomen. Of the internal organs, the heart, excretory organs of two kinds, and the ovaries or testes are essentially the same in the imago as in the advanced larva—every other organ and system of organs in the whole body is completely changed.

The appendages of the thorax and abdomen are already recognizable in an advanced larva. These are three pairs of unjointed dorsal appendages of the thorax, forming the siphons of the pupa and the wings and halteres of the imago, three pairs of ventral jointed appendages of the thorax, the legs of the imago, one dorsal pair on the eighth segment of the abdomen, and two ventral abdominal pairs in the composite mass called for convenience "ninth segment" of the abdomen, and probably formed of three segments. These two last are the gonapophyses of the imago—appendages of the supposed eleventh segment I have failed to make out in the larva. All these eight pairs arise alike as outfoldings of the epidermis ("hypodermis") into which mesoblastic tissues extend. They all lie upon the surrounding epidermis under the cuticle, and are variously folded according to the form of the appendage itself, and in the case of the six thoracic pairs they are lodged in depressions of the body-wall.

Of the dorsal thoracic appendages all three are at first plate-like, but the first pair soon roll up to form the tubular siphons. The rudiments of the halteres and of the wings differ chiefly in point of size, the wings being much the larger. The legs are more or less cylindrical from the first but much crumpled as shown in Weismann's figures of *Sarcophaga* (1). The dorsal appendages of the eighth abdominal segment, the future fins of the pupa, are plate-like bodies lying immediately beneath the cuticle of the larval siphon. The rudiments of the gonapophyses are rod-like bodies lying under the cuticle at the sides of the "ninth segment."

Of the mouth appendages it is more difficult to speak with certainty, for the cuticle of the larval mouth-parts is so hard that it is almost impossible to cut sections of this region. Suffice it to say that when the pupa has emerged from the larval cuticle, the head-appendages are all very much longer than the larval head they have come out of, and they must therefore have been in an exceedingly plastic condition towards the end of larval life, or else they must have been very much folded. Either condition would fully explain why the larva gave up eating.

The antennæ of the larva as seen from without are a pair of rather short rod-like organs with a thick cuticle. This cuticle prevents any apparent growth, but a very extensive growth nevertheless occurs, only as there is no room to grow forwards, growth occurs backwards and the basal portion is thrust into the head and telescoped and much folded.

At the time of escape of the pupa, the mouth-parts, antennæ, wings, halteres and legs become straightened out and laid beneath the thorax and upon its sides, the legs only being folded. The fins and pupal siphons take on their final form and at once come into use. The mouth-parts which are cemented together are much longer than the thorax and their distal ends are turned upwards under the anterior part of the abdomen, leaving a space between them and the ventral surface of the body. The wings are also much longer than the thorax and they extend down at each side of the mouth-parts, forming side walls to the cavity of which the mouth-parts form the floor. This cavity is partially occupied by the legs, the remainder of it is *filled with air* and serves as a float.

All the mouth-parts of the imago are present in the youngest pupa and are indeed much larger than in the adult. The pulpy tissue with which they are filled rapidly contracts and the new cuticle is then formed. The hypopharynx is at first continuous with the labium but rapidly separates in the female (not in the male) and in both sexes the salivary groove is formed upon its anterior surface, and at the point of opening of the salivary duct (S, fig. 7) a thickening of the epidermis appears, becomes hollow, acquires a chitinous lining and dilator muscles and forms the organ for injecting the saliva into the wound. The soft parts within the mandible of the male appear to be completely absorbed and the imago has no mandible.

The antennæ arise in front of the compound eyes and are laid back on the sides of the thorax, their hinder ends being hidden by the wings. The cuticle shows a distinct but not obvious jointing, the basal joint being the largest. The pulpy tissues within rapidly shrink away from the cuticle and a new cuticle is formed within, clothed with small hairs in the female and with very large ones on the second to the thirteenth segments in the male. During this shrinking the segmentation of the imaginal antennæ loses its correspondence with that of the pupal cuticle, the two terminal segments, which are devoid of long hairs, becoming much longer than the other thirteen. The basal joint or "ear" I will describe with the sense organs.

The prothoracic siphons (*At.* fig. 1) are nearly cylindrical tubes, narrower at their bases and arising from a pair of slight prominences on the sides of the thorax. The outer surface is marked so as to give the idea of imbricated scales, each scale ending in a minute spine. The distal end of the tube is somewhat obliquely truncate and is notched on its inner side. The inside of the tube is beset with numerous small curved spines, and the cavity communicates with the tracheal system. These organs are shed with the pupal cuticle, and their walls are almost all cuticle, the layer of epidermis and mesoblast, if there is any, is extremely thin, and Palmén's statement (2) that the organ is a gill is absurd.

The wings are plates of the form shown in fig. 1. They are fairly thick and the imaginal wings within them, while diminishing very greatly in thickness, increase largely in surface and so become much folded. They also develop scales. The halteres are wing-like triangular plates of considerable size (*Hr.* fig. 1) and the imaginal organs within are also at first flat plates. They acquire their final form during pupal life.

The legs are folded upon themselves, not as in the larva but regularly, the coxae are directed backwards, the femora forwards, the tibiæ backwards, and the tarsi curved inwards, the hinder ones being folded like an S. These parts are sharply marked off from one another by distinct joints, as also are the successive joints of the tarsi. Like the other appendages the imaginal parts within shrink considerably and the correspondence between the segmentation of the imaginal cuticle and that of the pupal cuticle is soon lost, the lengths of the different joints varying more in the imago than in the pupa.

The gonapophyses are not recognisable externally in the pupa. Both pairs are enclosed in one pair of large outgrowths of the "ninth segment," much larger in the male than in the female. The imaginal parts shrink greatly and the outer (or dorsal) pair become two-jointed and acquire a clothing of stout bristles. Like the appendages the whole body shrinks within the pupal cuticle and especially the head.

The chief internal organs of a very young female pupa (*i.e.*, under ten minutes old) are shown in sagittal section in fig. 7. The alimentary canal undergoes a remarkable series of changes. The mouth is closed. The buccal cavity (*B*) becomes narrower where it passes through the nerve collar. Behind this it becomes triangular in transverse section, and flattened from side to side, and acquires a thick chitinous lining with powerful dilator muscles in the female, attached to its sides and to its narrow roof. The same form is found in the male but much smaller.

The œsophagus, that is the short tube from the cervical constriction to the beginning of the stomach, elongates and becomes slightly folded. From its hinder part, close to its opening into the stomach, a blind sac grows out ventrally and rapidly extends back under the stomach to the hinder part of the thorax, and numerous sacculations develop along its sides. This is the "crop" of the imago. No trace of it is to be seen in the youngest pupæ. The stomach is sharply marked off from the œsophagus by a constriction, and in the young pupa by the character of its epithelial cells (see fig. 7). During pupal life the epithelium splits into two layers (see figs. 3 and 4) and the inner layer, by far the thicker, undergoes disintegration and is digested (fig. 5), so that at the end of pupal life hardly a trace of it is left (fig. 6). In the intestine the epithelium is longitudinally folded and the change is more difficult to make out. Here also the splitting of the epithelium and disintegration of its inner layer occur.

In the rectum more complex changes occur, and the tube, which was at first of almost uniform diameter throughout, becomes differentiated into a very wide anterior portion, the rectal pouch, and a narrow posterior portion the rectum proper. The wall of the rectal pouch at the same time becomes as it were pushed in at four points so as to project in the form of four papillæ into the cavity. The epithelium of these rectal papillæ (or "rectal glands") becomes highly specialised, its cells being very large and columnar. Mesoblastic tissues with tracheæ and nerves extend into the axis of each. Throughout both portions of the rectum the epithelium splits and the inner layer is shed. This layer is thick except over the papillæ where it is very thin and difficult to recognise, while the basal layer, which forms the permanent epithelium of the rectum is, except on the papillæ, so thin that it is difficult to see.

The salivary glands, at first simple pyriform sacs, become slightly branched, and their cavities become much narrowed. The paired ducts run from the glands in the anterior part of the thorax to a point just behind the subœsophageal ganglia, and then unite to form the median duct (*SD.* fig. 7) opening into the groove on the hypopharynx already described.

The circulatory system consists of heart and aorta. The heart is a tube running above the alimentary canal from the anterior end of the eighth segment forwards to the anterior end of the abdomen where it ends suddenly, giving off the aorta from its ventral border, and this runs forwards to end in the cerebral ganglionic mass. The hinder end of the heart is open, but I have not been able to discover valves here: they are however not easy to see elsewhere and it is probable that they really exist though I have not seen them (or *it*). At the anterior end, *i.e.*, in segment I., a pair of apertures open into the heart and are guarded by valves directed backwards. Similar valves, but directed forwards, guard paired ostia in segments III. to VII. inclusive, but I have seen neither valves nor ostia in segment II.

The heart is held in position by numerous filaments attached to the dorsal body-wall, and by *alæ cordis*. In what follows I am describing only what I have made out by the ordinary methods of dissection and section-cutting, and simple staining with picrocarmine, my object being to determine the anatomical rather than the histological characters of the pupa, and my views on histological points will therefore hardly have the same weight attached to them as those of the great investigator of Insect-hearts, Graber. Of the anatomical relations of the " septum " of Graber, I have however no doubt, though they are entirely different from those described by Graber (7) in other insects and generally regarded as universal. (See for instance Claus's Text-book of Zoology, where a figure of *Acridium* is given and spoken of as if the arrangement there shown were universally true of other insects.)

The heart consists of three layers. The innermost, the endocardium, is a single layer of exceedingly thin flat cells, easily recognised by their large nuclei of which four pairs are seen in each abdominal segment; similar but smaller nuclei are seen, one in each of the two flaps of each valve. The middle layer consists of fibres encircling the heart, what Weismann (op. cit., pl. xii. fig. 50) mistook in *Musca* for the striations of the single hollow striped muscle-cell of which he believed the heart to consist. The outer layer also consists of fibres, but their main direction is longitudinal, and they curve outwards on the dorsal surface to be continuous with the fibres of the alæ.

The alæ as seen from above, are triangular sheets running from the sides of the heart outwards: there are four pairs in each segment. In transverse sections they are seen to be double, the fibres of the upper sheet being continuous with those of the outer layer of the heart. The fibres of the lower sheet are in part directly continuous immediately beneath the heart, with those of the alæ of the other side, while in part they are attached to the heart itself. The two sheets extend from the heart outwards and downwards, and after uniting are attached to the "peritoneal" investment of the stomach and of the main tracheal trunks. They are certainly not attached to the body-wall, and the tracheal trunks certainly lie *above* them. I believe the fibres attaching them are muscular.

In the cavity between the dorsal and the ventral laminæ of the alæ are the large "pericardial cells" which Kowalevsky (3) regards as excretory. They are arranged in masses at the sides of the heart, four pairs of masses to each segment of the abdomen, i.e. one to each ala, and each mass has a number of nuclei (2 or 3 up to 8 or 10), though the cell-boundaries are not to be made out clearly. The protoplasm of the cells is markedly spongy, and contains numerous granules which stain deeply with carmine, and which Kowalevsky regards as excretory products.

The five Malpighian cæca have their blind ends lying free in the seventh or eighth segment: from this point each runs forwards to the anterior end of segment V., and then turns back to open into the commencement of the intestine. Each consists of two rows of very large cells which have an intense white colour due to minute granules of excretory matter. These organs undergo no marked change during the pupal period.

The respiratory system of the larva is, according to Raschke (4), three-fold. The rectum and the four gills around the anus have already been described. The gills are shed with the larval cuticle. The chief respiratory system consists, however, of tracheæ, the two very large main trunks of which run the whole length of the body and open to the exterior at the tip of the siphon. These are very large, and serve both as a store for air and as a float. They are connected by imperforate branches with the external cuticle at points on the sides of the body corresponding to stigmata. During larval life a new cuticular lining (" intima") is formed around the old one, and the old one is shed with the exuviæ.

The stigmata of the pupa through which the larval tracheal intima is drawn out immediately close, and the new intima of the branches connecting them with the main trunks collapses, so that the stigmata are functionless. One pair, those in the first segment of the abdomen, form an exception: they remain wide open, and the intima just within the stigmata is beset with numerous small curved spines. These stigmata open into the air-cavity between the wings and beneath the thorax and first portion of the abdomen, placing this cavity in direct continuity with the tracheal system generally: as, however, this cavity is always below the surface of the water, fresh supplies of air cannot be taken in through it.

From the base of the prothoracic respiratory siphons tracheæ with well-developed spirally-marked intima lead to all parts of the body—the most important ones being the two large longitudinal trunks running the whole length of the body. A transverse trunk runs from side to side, between the nerve-chain and the stomach, putting the cavities of the two siphons into direct communication with each other. To prove the continuity of the cavities of the siphons with that of the tracheal system generally, I removed the side-wall of the thorax from a spirit specimen, and having drawn out the spirit from the siphon with blotting paper, touched the tip with a small drop of glycerin, and I then saw the glycerin force its way into the siphon driving the air before it into the trachea. This I thought necessary because Palmén (op. cit.) has stated the contrary.

In the main trunks no important change occurs after the beginning of pupal life. The lateral branches leading to the stigmata enlarge and develop a stout intima around the thin collapsed old one, which latter is afterwards shed.

The fate of the soft parts of the larval siphon is much like that of the larval epithelium of the stomach. The whole mass was introverted into the eighth segment at the time of escape of the pupa. During pupal life it rapidly disintegrates and is completely absorbed so that no trace of it remains at the end of the fourth day.

The nervous system undergoes a great increase in bulk. At the moment of escape of the pupa the first abdominal ganglia shift bodily into the thorax—the distance is, however, only a very short one. During the pupal period the three pairs of thoracic ganglia and these from the abdomen grow considerably and fuse together to form one continuous mass, though its composite character is readily recognised in sections. The ganglia of the eighth segment gradually shift forwards, the connectives being absorbed, so that before the end of the four days of pupal life the eighth pair have fused with the seventh. At the moment of escape of the imago the composite mass thus formed shifts suddenly into the eighth segment in the female but remains in the seventh in the male.

The ganglia of the head increase enormously in size so as to almost fill the head. At certain places, especially at the margins of the eyes and at the bases of the antennæ, great thickenings of the epidermis are continuous with the ganglia, and the new cells of the ganglia would thus appear to be derived directly from the epidermis. The "brain" is also continuous, with the deeper cells in the basal joint of each antenna, and this mass in turn with the epidermis at the line of insertion of the antenna into the head.

The sense-organs of the larva are antennæ and hairs or setæ, and especially some at the end of the respiratory siphon. Those of the pupa are setæ and ocelli. Those of the imago are eyes, ocelli, maxillary palps, labellæ (the modified palps (?) of the labium), the antennæ with the ear, and the hairs upon the antennæ and the maxillary palps; possibly also the halteres.

I shall not describe most of these, but shall record just so much as appears to me to be of special interest. Of the setæ of the pupa, one pair on the first abdominal segment seem to be the organs by means of which the animal detects movements of the surface of the water. Each consists of a triangular basal plate attached to the soft cuticle just behind the first abdominal tergum. The distal side of the plate divides into a few setæ, which by repeated branching give rise to about one hundred straight setæ all lying in one plane parallel to the median axis of the body, and each bearing a few fine hairs. They are shown diagrammatically in fig. 1. When the pupa is at rest the tips of the setæ are just at the surface of the water.

Each antenna of the male imago consists of three portions. The swollen basal joint, a series of twelve joints bearing long hairs, and a terminal portion consisting of two long joints with only small hairs. A. M. Mayer (5) has shown by experiments upon mosquitos that when a tuning fork of a certain note ($Ut_4 = 512$ vibrations per second) was sounded these hairs were set in violent vibration, especially when the sound came in the direction of the axis of the antenna. This note corresponds pretty closely with the chief note produced by a special vocal organ on each side of the thorax of the female—not the "buzz" of the wings but a much higher note, and the antenna has therefore been regarded as an organ of hearing. The structure of the basal joint or "ear" supports this view, for it appears to be specially adapted for perceiving longitudinal vibrations of the shaft.

The "ear" is a nearly hemispherical cup with very thick walls which are turned in at the edge, the turning-in going so far in the male that the inturned portion reaches the floor of the cup and becomes closely applied to it. The strong chitinous covering of the rest of the body covers the whole surface of the cup and the shaft, but it is thinner on the inner than on the outer surface of the cup. The shaft is attached rigidly to the floor of the cup, and a series of radiating thickenings run in the floor from the base of the shaft outwards. A longitudinal vibration of the shaft would thus cause this plate to vibrate.

The soft parts within the ear, that is between the outer and the inner surfaces of the cup are:—

(i.) A thin epidermis.

(ii.) A thick layer of nerve-cells, continuous proximally with the supra-œsophageal ganglion.

(iii.) A layer of long thin rod-like cells, the inner ends of which are close to the floor of the cup, i.e. the vibrating plate, while their outer ends abut upon the nerve-cell layer.

(iv.) A very large nerve, broader than the ventral cord of the abdomen, which arises from the ventral part of the supra-œsophageal ganglion at the sides of the "œsophagus." This nerve is independent of the antennary nerve proper and lies dorsal to it. On entering the organ it divides into layers which lie, one in the middle of the nerve-cell layer and one between this layer and the bases of the rod-like bodies.

(v.) The antennary nerve proper, which simply passes through the basal portion of the organ to reach the shaft of the antenna.

This organ is already large in the larva. It arises as an infolding of the epidermis around the base of the antenna, and all the structures I have described in it are of epidermal origin. The differentiation of the rod-cells from the rounded nerve-cells however only occurs in the latter part of pupal life. In the female the infolding of the edge of the cup is not carried so far as in the male, so that there is a considerable space between the infolded margin and the floor of the cup. As to the function of this organ—the one object of existence of the male is to find and fertilise the female. In this he is assisted chiefly by this organ which recognises the sound of the female whenever his antennæ are turned in her direction, and hence he is guided by it in his flight directly towards her. The larger eyes will also, no doubt, help him when he is at shorter distances.

The compound eyes are already present in the larva, and in the pupa they rapidly increase in size till they almost envelope the head. The one point in their development of which I have convinced myself is that the growth consists in the addition of new elements at the edge, which arise by direct modification of the previously unmodified epidermis around the margin of the eye—epidermis whose last function was to secrete the pupal cuticle. The cells of this epidermis proliferate in groups, and the centre of each group becomes "invaginated," the four cells round the margin of the invagination persisting as the "nuclei of Semper" immediately beneath the corneal cuticle which they *appear* to secrete. The invaginated portion gives rise to all the other parts of the eye which lie outside the limiting membrane, with the probable exception of tracheæ and their "peritoneal" investment, and of the pigment cells.

During pupal life vision must be very imperfect, for both the compound eyes and the ocelli lie beneath the pupal cuticle and in the later stages are not even in contact with it. The ocelli ought probably to be regarded as the persisting visual organs of the larva, the compound eyes as the rudiments of organs to be first used when the imago emerges from the pupal exuviæ.

Of the reproductive organs, the ovaries (or testes) are present in the larva as a pair of fusiform bodies lying in the sixth segment (of the abdomen) at the sides of the intestine. Each is enveloped in a "peritoneal" layer of flattened cells. During pupal life this investment grows backwards to form the paired oviducts of the female, or the anterior part of the vasa deferentia of the male. The remaining organs of the female are a median oviduct (often called "vagina"), a copulatory pouch, and three spermathecæ.

The median oviduct begins during the larval period, as an invagination of the body-wall in the region which I take to correspond to the junction of the eighth and ninth sterna. At the commencement of pupal life (fig. 7) it already extends forwards to the anterior end of the eighth segment, and during pupal life it continues to advance till it reaches to the middle of the seventh segment, all this time keeping pace with the forward movement of the fused seventh and eighth abdominal ganglia, the anterior end always lying beneath the hinder end of this mass. The sudden forward movement of the mass into the sixth segment at the time of escape of the imago however leaves it behind.

The copulatory pouch is a small upward and backward diverticulum of the hinder end of the median oviduct. Three flattened forward outgrowths from it lie upon the median oviduct, in the hinder half of segment VIII. at the commencement of pupal life. During this period they become longer and narrower and folded upon themselves, and their anterior ends become dilated to form hollow spheres lined with a thick rigid layer of chitin! These three bodies are the "spermathecæ"—how the seminal fluid can be forced into them and injected from them is, to me, a mystery.

The male organs are the testes and anterior part of the vasa deferentia already mentioned, the hinder portions of the vasa deferentia, the "prostatic" glands, the copulatory organ, and a common pouch at its base into which the vasa deferentia and the prostatic glands open.

The testes are chambered organs, the spermatozoa in the hinder chambers being more advanced in development than those in the anterior ones, and these hinder chambers seem to take the place of vesiculæ seminales. In another gnat, the genus of which I did not determine, the hinder portions of the vasa deferentia were swollen out to form large vesiculæ seminales, which arrangement however, I have not found in any of the *Culices* I have examined.

The hinder parts of the two vasa deferentia, corresponding to the vesiculæ just mentioned are in *Culex* closely united together, and they are formed by invagination of the region which I take to be tenth sternum, or just behind it. The same invagination gives rise to the common pouch (or ejaculatory pouch), and the vasa deferentia (hinder portions) are, as well as the "prostate" glands, outgrowths of it. The walls of this portion of the vasa deferentia are thick and apparently glandular, and the two cohere closely, though transverse sections show their cavities to be quite separate. The prostate glands are elongated bodies, extending forwards to the hinder part of the seventh segment. In transverse sections each is seen to have two cavities, which however unite behind before opening into the common pouch.

Of the nature of the copulatory organ itself I am very uncertain; apart from the two pairs of gonapophyses there is an inner organ, on the under surface of which is the male genital aperture. This looks like a pair of fused appendages representing an eleventh segment of the abdomen, but I do not feel justified in doing more than suggesting this as a possibility. As to the mode of use I am ignorant, having never seen it in use, but the best of my sections suggest that the hindermost portion of the ejaculatory duct, behind the common pouch, is eversible.

List of Works referred to in Foregoing Paper.

1. *Weismann.* Die Entwicklung der Dipteren. Leipzig, 1864.
2. *Palmén.* Zur Morphologie des Tracheensystems. Helsingfors, 1877.
3. *Kowalevsky.* Ein Beitrag zur Kenntniss der Excretions-organe. Biolog. Centralblatt. Bd. IX. 1889.
4. *Raschke.* Die Larve von *Culex nemorosus.* Berlin, 1887.
5. *A. M. Mayer.* Researches in Acoustics. American Journal of Science and Arts, 1874.
6. *Grenacher.* Untersuchungen über das Sehorgan der Arthropoden. Göttingen, 1879.
7. *Graber.* Ueber den propulsatorischen Apparat der Insecten. Archiv für mikroskopische Anatomie. Bd. IX.

NOTE.—The substance of the foregoing communication has been printed in the second volume of the "Studies from the Biological Laboratories of the Owens College," and has formed my inaugural dissertation for the Degree of Ph. D. in the University of Leipzig. For permission to reprint the plate I have to thank Professor Marshall, the editor of the "Studies."

Explanation of Plate V.

Fig. 1. Side view of the male pupa (× 10).

Fig. 2. Ventral view of the female pupa, partially extended (× 10).

Figs. 3 to 6. Successive stages in the metamorphosis of the epithelium of the hinder part of the stomach (× 225).

Fig. 7. Sagittal section of a very young female pupa (× 50).

Ant. antenna; *Ao.* aorta; *At.* respiratory siphon; *B.* buccal chamber; *CG.* cerebral ganglion; *D.* gastric pouch; *F.* fin; *Fe* 1. femur of the first leg; *G.* ganglia; *Gn.* outgrowth of "ninth segment," within which the gonapophyses develop; *Hr.* halter; *H.* head; *Ht.* heart; *In.* intestine; *Lb.* labium; *Lbr.*, *Lr.* labrum; *M.* Malpighian cæcum; *M.Ap.* its opening into the intestine; *MS.* mesosternum; *Mt.* metasternum; *Mx.* maxilla (first); *Mxp.* its palp; *NC.* nerve connectives and ventral cord; *Oc.* ocellus: *Od.* median oviduct ("vagina"); *Op.* compound eye; *P.* prosternum; *R.* rectum; *S.* aperture of salivary duct; *SD.* salivary duct; *SG.* subœsophageal ganglion; *Si.* larval respiratory siphon introverted into eighth segment; *Sp.* spermathecæ; *St.* stomach; *Ta* 1, *Ta* 2. proximal joints of tarsi of first and second legs; *Ti* 1, *Ti* 2, *Ti* 3; Tibiæ, *Tr.* Tracheæ; *W.* Wing.

I., II., III., etc., first to eighth segments of abdomen.

THIRD REPORT on the PORIFERA of the L.M.B.C. DISTRICT.

By Richard Hanitsch, Ph.D.,
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With Plates X.—XV.

[Read 9th May, 1890.]

In the two previous reports* on the Porifera of the district forty-four species were recorded, one of which was new to British seas and three new to science. Several cruises in Liverpool Bay during the summer of 1889 and the present spring, and also shore-working at the Biological Station, Puffin Island, in April, 1889, and at Port Erin, Isle of Man, last April, enable me to add twelve species to the record, three of which are new to science, making in all fifty-six species.

In my former report I fell into a serious error in regard to the structure and systematic position of *Seiriola compacta*, n. sp., and I desire to acknowledge my indebtedness to Professor Sollas, D. Sc., for the great kindness with which he has pointed out the mistake to me and has answered many questions having a bearing on that species. I give now a re-description of *Seiriola compacta* (see below).

The following table gives all sponges found up to the present date in the district, and shows the distribution of the species in the four parts in which they have been most

* "Report on the Porifera of the L.M.B.C. District." by Thomas Higgin, F.L.S., in "Fauna of Liverpool Bay," Vol. I., 1886. And "Second Report on the Porifera of the L.M.B.C. District," by R. Hanitsch, in Proc. Biol. Soc., Liverpool," Vol. III., 1889, and "Fauna," Vol. II.

carefully collected. There is nothing very striking in the distribution. The estuaries of the Mersey and the Dee are by far the poorest in Porifera, as might have been expected. But it is rather surprising that up to now only one tetractinellid sponge (*Pachymatisma johnstonia*, B.) has been recorded from the Isle of Man. Most probably there are numbers of Tetractinellida living on the rocky shores of that island, and simply requiring to be sought for. The north-east corner of our district has, as far as I know, not yet been specially searched for sponges, so that only two species are recorded from Morecambe Bay. These are: *Chalina oculata*, J. and *Suberites domuncula*, N. I have not thought it necessary to give in the table a special column to that locality. Puffin Island is only separated from the North Wales column in order that there may be a record of the species found in the immediate neighbourhood of our Biological Station. In all twenty-six species have now been found on the shores of the island.

The lists in the former reports included the species *Halichondria coccinea*, B., which had been collected in Belfast Lough. I shall leave it out in the present report, as that species has not yet been found inside the boundaries of our district. Also *Papillina suberea*, S., has now been left out as it is merely a synonym for *Cliona celata*, Gr. I shall adhere to the classification employed in the previous report, but the nomenclature of the species differs in a few instances. I now use:—

Spongelia fragilis, M.,	instead of	*Dysidea fragilis*.
Chalina pallida. B., ...	,,	*Chalinula pallida*.
Chalina densa, B., ...	,,	*Chalinula densa*.
Amphilectus incrustans, J.,	,,	*Desmacidon incrustans*.
Esperella ægagropila, C.,	,,	*Esperia ægagropila*.
Suberites domuncula, N.,	,,	*Suberites suberea*, M.
Dercitus bucklandi, B.,	,,	*Dercitus niger*, C.

List of Porifera recorded from the L.M.B.C. District.

Order I. **MYXOSPONGIÆ.**	Estuaries of Mersey & Dee.	Isle of Man.	North Wales.	Puffin Island.
Family.				
HALISARCIDÆ—*Halisarca dujardini*, J.	×	×	×	×
Halisarca rubra, n. sp.	...	...	×	...
Order II. **CERATOSA.**				
SPONGELIDÆ—*Spongelia fragilis*, M.	...	...	×	×
Order III. **MONAXONIDA.**				
Subord. HALICHONDRINA.				
HOMORRHAPHIDÆ—*Halichondria panicea*, J.	×	×	×	×
Halichondria albescens, J.	...	...	×	...
Halichondria caruncula, B.	...	×	×	...
Reniera varians, B.	×	...	×	×
Reniera elegans, B.	...	×	...	...
Reniera simulans, J.	...	×	...	...
Reniera fistulosa, B.	...	×	×	...
Reniera clava, B.	...	×	...	...
Reniera semitubulosa, S.	...	...	×	×
Reniera ingalli, B.	...	×	...	...
Chalina oculata, J.	...	...	×	...
Chalina limbata, M.	...	×	×	×
Chalina montagui, T.	...	×	...	...
Chalina pallida, B.	...	×	...	...
Chalina densa, B.	...	×	×	...
Chalina gracilenta, B.	...	...	×	×
HETERORRHAPHIDÆ—None.				
DESMACIDONIDÆ—*Desmacidon fucorum*, J.	...	×	×	×
Esperella ægagropila, J.	...	...	×	...
Esperella floreum, B.	...	×	...	...
Amphilectus incrustans, J.	...	×	×	×
Clathria seriata, J.	...	×	×	×
Plumohalichondria plumosa, C.	...	...	×	...
Plumohalichondria atrasanguinea, B.	×	...	×	×
AXINELLIDÆ—*Hymeniacidon sanguinea*, J.	...	×	×	...
Axinella mammillata, n. sp.	...	...	×	×
Raspailia ventilabrum, B.	...	...	×	...
Raspailia rigida, M.	...	×	×	×

Subord. CLAVULINA.	Estuaries of Mersey & Dee.	Isle of Man.	North Wales.	Puffin Island.
SUBERITIDÆ—*Suberites carnosa*, J.	×	...	...	...
Suberites domuncula, N.	×	×	×	×
Suberites ficus, E.	...	...	×	...
Cliona celata, Gr.	...	×	×	×
Polymastia mammillaris, J.	...	...	×	×
Polymastia robusta, B.	...	...	×	...
SPIRASTRELLIDÆ—None.				
Order IV. **TETRACTINELLIDA.**				
Subord. CHORISTIDA.				
TETILLIDÆ—*Tethya lyncurium*, J.	...	...	×	...
PACHASTRELLIDÆ—*Dercitus bucklandi*, B.	...	...	×	×
STELLETTIDÆ—*Seiriola compacta*, Hn.	...	...	×	×
Stelletta grubei, S.	...	...	×	...
Stelletta collingsi, B.	...	...	×	×
Ecionemia ponderosa, B.	...	...	×	...
GEODIIDÆ—*Pachymatisma johnstonia*, B.	...	×	×	×
Subord. LITHISTIDA.				
None.				
Order V. **HEXACTINELLIDA.**				
None.				
Order VI. **CALCAREA.**				
ASCONIDÆ—*Ascetta coriacea*, F.	...	×	×	×
Ascaltis botryoides, F.	...	×	×	...
Ascaltis contorta, B.	×	...	×	...
Ascortis lacunosa, J.	...	...	×	×
LEUCONIDÆ—*Leucandra fistulosa*, J.	...	×	...	...
Leucandra gossei, B.	...	×	×	...
Leucandra nivea, F.	×	×	×	×
Leucandra johnstoni, C.	...	×	×	...
Leucaltis impressa, n. sp.	...	...	×	×
SYCONIDÆ—*Sycortis aspera*, G.	...	×	...	...
Sycandra ciliata, F.	×	×	×	×
Sycandra compressa, F.	...	×	×	×
Aphroceras ramosa, C.	...	...	×	...

Order I. MYXOSPONGIÆ.

Halisarca rubra, n. sp. (Pl. X., figs. 1 and 2.)

New species of *Halisarca* have been described so frequently, which have afterwards been shown not to belong to that genus or even not to exist at all, that it is with some reluctance that I establish the new species *Halisarca rubra*. The specimen was dredged on the "Spindrift" Expedition in July, 1889, off Holyhead, from a depth of about fifty fathoms. It encrusted both valves of a living *Mytilus edulis* with thin brick-red patches, the entire thickness of the sponge being 0·45 mm. Its surface showed a somewhat wavy outline, which condition was apparently solely caused by the hairs of the *Mytilus* projecting through it, and the sponge growing for a short distance upwards along those hairs. Oscula and pores were not visible to the unaided eye.

Vertical sections showed that the outer portion of the sponge had suffered, so that its structure could not be made out satisfactorily. The figure (see Pl. X., fig. 1) of it therefore is somewhat diagrammatic. The inner and greater portion of the sponge was well preserved (Pl. X., fig. 2). There is a "dermal membrane" between the outer world and subdermal cavities, about 0·014 mm. in thickness. The subdermal cavities are flat, and seem to be distinct from the wide irregular cavities of the canal system. Oscula and pores could not be detected. The flagellated chambers are round or oval, with a diameter of 0·08 to 0·14 mm. The size of the collar-cells, of which however the collars and flagellæ were never seen distinctly, is about 0·006 mm. The mesoderm consists of fibrous tissue. Imbedded in it are large red pigment-cells, 0·02 to 0·026 mm. in size, more or less oval and pretty numerous. Their nuclei are small, and sometimes only indistinctly seen.

In sections prepared without staining the pigment-cells have preserved almost their natural colours.

The only acknowledged species of *Halisarca* is the well-known cosmopolitan *Halisarca dujardini*. It has been re-described and figured (after Schulze) by Lendenfeld,* but there seems to be a good deal of difference between it and *H. rubra*. In *H. dujardini* the cavities of the canal system are not distinct from the subdermal cavities, and the flagellated chambers are irregularly tubular and branched. It may be that my new species belongs to the genus *Bajulus*, Lendenfeld (loc. cit. p. 724), in which there are distinct subdermal cavities and regularly oval flagellated chambers.

Although none of Carter's species of *Halisarca* have been acknowledged by Lendenfeld, still it ought to be remembered that Carter described two red species of *Halisarca*. The one is *Halisarca rubitingens*, C,† from the Gulf of Manaar. Carter describes it as "amorphous, indefinitely spreading and agglomerating together everything in its course, at the same time that the whole is tinged externally by its red colour, appearing in the form of a thin membrane when stretched across cavities, composed of polygonal divisions (cells) in juxtaposition, filled with granular contents in which the pigment is situated." The other red species is *Halisarca cruenta*, C.,‡ from the Gulf of Suez. Carter says about its colour: "crimson colour of the surface, which is seated in an extremely thin cuticula, fading off into grey internally." Evidently in both of Carter's species the pigment is placed in the ectoderm, and

* R. v. Lendenfeld, "A Monograph of the Horny Sponges," p. 728, Pl. 50, fig. 2.

† Carter, "Annals and Magazine of Natural History," 5th ser., vol. vii., p. 366.

‡ Carter, loc. cit., vol. viii., p. 247.

therefore they cannot be identical with *Halisarca rubra.*

It is well known that the colour in Sponges is sometimes caused by ova.* Still that could scarcely be the explanation of the red cells in *Halisarca rubra*, as the nuclei of the cells in question are much too small to be the germinal vesicles, and in general appearance the cells did not resemble ova.

Order II. **CERATOSA.**

Spongelia fragilis, Montagu.

To the two localties where this species had been found previously, Church Bay, near Holyhead, and Puffin Island, I am able to add now Penrhos Bay, Anglesey, where we dredged it on the "Hyæna" Expedition of May 25th, 1890.

This form is probably identical with Lendenfeld's † *Spongelia fragilis* var. *irregularis.* Still there is some difference in the colour. Lendenfeld says in regard to his variety, "the colour of the living sponge is dull violet-red on the surface and yellowish in the interior." My specimens are of a yellowish sand-grey throughout.

Order III. **MONAXONIDA.**

Reniera varians, Bowerbank.

This species, which has been recorded from the Mersey and Hilbre Island, has now been discovered also at Puffin Island. I found one specimen hanging from a ledge of rock at the north end, below the Biological Station, in April, 1889. The under surface of this particular rock was literally covered with other species of sponges : *Clathria seriata*, *Plumohalichondria atrasanguinea*, *Amphilectus incrus-*

* Carter, "Notes Introductory to the Study and Classification of the Spongida, A.M.N.H.," 4th ser., vol. xvi., p. 37.

† R. v. Lendenfeld, "A Monograph of the Horny Sponges," p. 662.

tans, *Raspailia rigida*, *Leucandra nivea*, *Sycandra ciliata*, and *Sycandra compressa*.

A great number of very fine specimens were collected again at Hilbre Island on March 21st, 1890, although this species had not been seen there for several years.

Reniera ingalli, Bowerbank.

Isodictya ingalli, Bowerb., Brit. Spong., vol. iii., p. 241, pl. lxxviii.

Bowerbank gave his description from three dried specimens which had been sent to him from Southport. The one specimen, which I found in a tidal pool at Port Erin, April, 1890, has quite the appearance of that figured by Bowerbank, although it is only about one-half the length. Its colour, when alive, and also after having been kept in spirit, is a brownish-yellow. It is hard and stony to the touch. The spicules are slightly curved, and rather bluntly pointed oxea, measuring 0·15 by 0·009 mm. They are held together by a rather large amount of ceratose, and form somewhat irregular meshes, which may be unispicular or bispicular. The width of the oscula varies from 1 to 2 mm.

Chalina gracilenta, Bowerbank.

This species is new to our district and was first described by Bowerbank,* who collected it at Torbay, Scarborough, coast of Northumberland, and Hastings. Oscar Schmidt † seemed to have some doubts about its systematic position or even its existence, but I am able to confirm Bowerbank's statements in regard to both points.

I found one specimen of *Chalina gracilenta* at the northeast end of Puffin Island, April, 1889, in one of the tidal pools, where it was attached to *Corallina officinalis*. It formed an encrusting mass of oval shape, 11 mm. by 5 mm., of yellowish-grey colour.

* Bowerbank, "British Spongiadæ," vol. ii., p. 372, and vol. iii. p. 171.

† Oscar Schmidt, "Spongienfauna des Atlantischen Gebietes," p. 77.

This species is a very interesting one, as from a superficial examination with a low power one might think it a ceratose sponge. Even with a high power the spicules are difficult to recognize in the thick ceratose fibres, whilst in other species of *Chalina* they are seen well with a low power. The thickness of the ceratose fibres is 0·02 to 0·075 mm. The spicules are extremely thin oxea, 0·07 by 0·002 mm. The width of the ceratose meshes varies from 0·15 to 0·30 mm.

If Lendenfeld* is right in his theory, as he most probably is, that "the skeleton of the Spongidæ was developed from that of the Homorrhaphidæ by the entire replacement of the spicules by spongin," then we must certainly think of forms like *Chalina gracilenta*, which lost the small traces of spicules they still possessed, whilst simultaneously essential changes in the canal system took place, and thus became changed into Ceratosa. In regard to the changes of the canal system, especially the change of the small flagellated chambers of the Monaxonida into the large sac-shaped ones of the Ceratosa, we may perhaps accept the mechanical explanation which Keller † gives in a recent paper. As a ceratose skeleton has certainly less rigidity than a siliceous one, the flagellated chambers of the Ceratosa are more liable to become compressed, and to be seriously affected in their function, than those of the siliceous sponges. An increase in size of the flagellated chambers would therefore be of advantage, as even under pressure some parts of them would remain expanded and functional. Keller's theory accounts well enough for the large flagellated chambers of the Ceratosa and Myxospongiæ, but scarcely for those of the Hexactinellida, which seem to

* R. v. Lendenfeld, "A Monograph of the Horny Sponges," p. 770.

† Conrad Keller, "Die Spongienfauna d. rothen Meeres." 1. Hälfte. Zeitschr. f. wissensch. Zoologie, 48, Band, 3. und 4. Heft.

have acquired both large flagellated chambers and a rigid siliceous skeleton.

Chalina montagui, Johnston. (Pl. XI., fig. 1.)

Halichondria montagui, Johnst., Brit. Sponges, p. 99, pl. vi.

Chalina montagui, Bowerb., B. S., vol. ii., p. 366; vol. iii., pl. lxviii.

This species is an addition to the Fauna of our district. I found it in a large and rocky tidal pool at Port Erin, April, 1890. Johnston records it as "not uncommon in the estuary of Kingsbridge at very low water, adhering to stones, and is occasionally taken by the trawl in the open sea on the coast of Devon, Conamara, and Dublin Bay." Bowerbank adds to those localities Brighton and Hastings.

The figure of the sponge, which I give in natural size on Pl. XI., was drawn by me from a photograph which Dr. Kohn (Chemical Laboratories, University College, Liverpool) had kindly taken from the specimen after it had been in spirit for some time. The specimen is larger than the one figured by Johnston, and differs from it in having shorter and less whip-like tubular portions. Bowerbank's figure had been taken from a rather poor specimen.

The colour of the living specimen was straw-yellow. The oscula are always placed on the extremity of conical elevations, and measure 3 mm. in diameter.

The spicules are mostly oxea, but a number of styli are also present. Both kinds of spicules are slightly curved, and measure on an average 0·096 by 0·008 mm. They are imbedded either in ceratose or in the so-called ascending fibres. Inside the ceratose the spicules are arranged in unispicular rows. The thickness of the ceratose fibre is 0·007 to 0·036 mm. The diameter of the ceratose meshes varies from 0·05 to 0·1 mm. The ascending fibres extend throughout the whole mass of the sponge, and give off branches in all directions. Their diameter is 0·05 to 0·08 mm. Inside those ascending fibres the spicules are arranged in about five longitudinal parallel rows. These fibres seem to consist only of connective tissue and spicules. Ceratose does not appear to be present in them.

Esperella floreum, Bowerbank.

Hymeniacidon floreum, Bowerbank (vol. ii., p. 190).

Rhaphiodesma floreum, Bowerbank (vol. iii., p. 94).

This species is an addition to our fauna, and was dredged off the Calf of Man, on the "Hyæna" cruise of Easter, 1889. Another species of the same genus, *Esperella ægagropila*, J., had previously been collected at Holyhead.* Our species was first described by Bowerbank, under the name *Hymeniacidon floreum*, which was afterwards changed by the same author into *Rhaphiodesma floreum*. Oscar Schmidt † was the first who pointed out that this species, together with *Hymeniacidon lingua* and *Hymeniacidon subclavata* belonged to Nardo's older genus *Esperia*. In the course of time the genus *Esperia* had to be changed into *Esperella*,‡ so that we now arrive at the name *Esperella floreum*, B.

Our specimen was found encrusting a living *Pecten opercularis*, with a thin and rugged layer of greyish colour. The thickness of this layer is about 1 mm. The skeleton consists of megascleres and microscleres. The former are styli (0·24 mm. by 0·008 mm.), which lie in irregularly arranged and loose bundles. The microscleres consist firstly of anisochelæ, which are arranged in beautiful rosettes. Similar structures are found in *Esperella lingua*, B.,§ in *Jophon abnormalis*, Ridley and Dendy,‖ and in

* Thos. Higgin, "Report on the Porifera of the L.M.B.C. District." In "Fauna of Liverpool Bay," vol. i., p. 85.

† Oscar Schmidt, "Spongienfauna des Atlantischen Gebietes," 1870, p. 76.

‡ Vosmaer, "Bronn's Klassen u. Ordn. d. Thierreichs, Porifera," p. 353.

§ Bowerbank, "British Spongiadæ," vol. i., pl. xviii., fig. 297.

‖ Ridley and Dendy, "Report on the Monaxonida, collected by H. M. S Challenger," pl. xvii., fig. 7.

Desmacidon titubans, Schmidt.* The length of the isolated anisochelæ in *Esperella floreum* is 0·036 mm. Besides those microscleres we find also simple sigmata, 0·06 mm. in length. Lastly there appeared to be present also a most minute kind of microscleres, but, on account of their smallness, I could not make out whether they were sigmata or chelæ. They measure 0·008—0·016 mm. in length. Possibly they are simply younger stages of the large anisochelæ and sigmata.

In no other species of sponge did I ever see such great masses of ova and developing embryos (morulæ) as in *Esperella floreum*. The ova are placed quite close to each other so that one might almost speak of ovaries, and they lie near to the limiting membrane, "in the position of greatest security." The morulæ are nearer to the surface. It was interesting to me to find that the greatest part of Ridley's and Dendy's "Embryological Notes" † is taken from the examination of some species of *Esperella*. These authors found that in large and massive sponges, like *Esperella lapidiformis*, where the position of the ova and embryos is a matter of no very great importance, so long as they do not lie near to the surface, those elements are scattered through the whole of the choanosome; whilst in a small and delicate species, like *Esperella biserialis*, the embryos take refuge in the centre of the spicular axis. Further they state, that in *Esperella mammiformis* the embryos are found grouped close to the stone to which the sponge is attached, near the centre of the base.

Our species has been recorded by Bowerbank from East Loch, Tarbet, Harris, and Strangford Lough.

* Carter, "Ann. and Mag. Nat. Hist., ser. 5, vol. ix., pl. xii., fig. 24.

† Ridley and Dendy, loc. cit., p. 4.

Amphilectus incrustans, Johnston.

Halichondria incrustans, Johnston.
Halichondria saburrata, Johnston.
Halichondria panicea, Grant.
Desmacidon incrustans, Schmidt.

This species seems to be of world-wide distribution. Higgin* states that it has been found in the West Indies and Falklands Islands; Bowerbank † records it from Frith of Forth, Hebrides, Orkneys and Shetland Islands, Welsh and Irish Coasts, Channel Islands, and Hastings. Further, it has been previously collected in two parts of our district, at Port Erin and Holyhead, and now I am able to add also Puffin Island to the list.

This sponge has been described or mentioned by Grant, Johnston, Bowerbank, Carter, and Higgin under the genus *Halichondria*. But Oscar Schmidt recognized that it, together with eighteen other of Bowerbank's species of *Halichondria*, belongs to the Desmacidonidæ, and accordingly, in my " Second Report," &c., I called this sponge *Desmacidon incrustans*. However, as I intend to follow Ridley and Dendy's principles of classification as far as possible and to accept their definitions of genera, I find it now necessary to remove our species to the genus *Amphilectus*, Vosmaer, ‡ also one of the Desmacidonidæ. In doing so I think it advisable to repeat what Ridley and Dendy say in regard to this genus :—" We make use of this genus in the manner indicated by its founder, namely, as a provisional receptacle for a number of doubtful Desmacidonidæ."§

* Higgin, " Report on the Porifera," in " Fauna of Liverpool Bay," p. 84.

† Bowerbank, ' British Spongiadæ," vol. ii., p. 249.

‡ For definition of the genus *Amphilectus* see Vosmaer, " Notes from the Leyden Museum'" vol. ii., p. 109.

§ Ridley and Dendy, " Report on the Monaxonida collected by H.M.S, Challenger,' " p. 123.

Amphilectus incrustans is fairly plentiful at Puffin Island, where it is found encrusting the rocks at about low-water mark (April, 1889). The colour is straw-yellow, and a kind of meandering marking on its surface is very characteristic. These markings seem to be caused by the alternate presence and absence of spicules. There are two kinds of megasclera: firstly tornotæ, measuring 0·19 mm. by 0·005 mm., which are found chiefly in the ectosome, and project with about half of their length beyond the ectoderm. And further: spined styli, measuring 0·195 mm. by 0·008 mm., which are found scattered irregularly through certain districts of the choanosome. The microcleres consist of palmate isochelæ (0·034 mm.) and simple sigmata (0.02 mm). I found also a few anisochelæ, but I am not quite sure whether they belong to the sponge. Ceratose is present in a small amount and is best seen in very thin sections. The arrangement of the spicules is rather remarkable, as they are found only in certain tracts which stand at right angles to the surface. Alternating with those spiculated portions we find tracts of tissue which are quite devoid of spicules, and these latter tracts seem to be wider than the spiculated ones. The alternate arrangement of these tracts causes, I think, the meandering marking on the surface of the sponge. The diameter of the oscula is about 1 to 2 mm.

A red coloured and elastic sponge which I collected at Port Erin, April, 1890, apparently belongs to the same species.

Clathria seriata, Johnston.

Halichondria seriata, Johnston.
Spongia seriata, Grant.
Chalina seriata, Bowerbank (vol. ii., p. 376).
Ophlitapsongia seriata, Bowerbank (vol. iii., p. 167).

In my previous report', in giving the list of the Porifera recorded from the L.M.B.C. district, I placed the sponge referred to by Mr. Higgin under the name *Ophlitaspongia seriata*, under the genus *Clathria*, Schmidt. Having found this form in profusion at Puffin Island, April, 1889, and at Port Erin, Easter, 1889 and 1890 (at both places for the first time), I am able to give now a further account of its systematic position.

I may use the same words in regard to this species which were used by Ridley and Dendy* about *Clathria inanchorata*: "Although it possesses no chelæ, yet this species agrees so closely with the genus *Clathria* in other respects that we have deemed it advisable to include it in that species, it is perhaps a form that once possessed isochelate microsclera and has now lost them." And this *Clathria inanchorata* is the only Desmacidonid sponge which forms an exception to Ridley and Dendy's definition of the family Desmacidonidæ. Their definition runs as follows (page 62):—"Desmacidonidæ: Megasclera of various forms, usually monactinal. Microsclera always present and always including chelæ." Then they add in a footnote: "We have included one or two species without chelæ on the supposition that they have had them and subsequently lost them." I would prefer the exception to be included in the definition proper of the family, especially as we do not know whether their "supposition" corresponds to phylogenetic facts. For that reason I am inclined to accept rather Lendenfeld's † definition of the Desmacidonidæ: "Cornacuspongiæ with a supporting skeleton composed of spiculiferous, often echinated fibres. Generally with chelæ in the ground substance. If chelæ are absent, the fibres are echinated by projecting spicules."

* Ridley and Dendy, "Report on the Monaxonida collected by H.M.S. 'Challenger,'" p. 150.

† R. v. Lendenfeld, "Descriptive Catalogue of the Sponges in the Australian Museum, Sydney," p. 210.

Our *Clathria seriata* fits in very well in Lendenfeld's definition of the Desmacidonidæ, and agrees also with the generic characters of *Clathria* as given by the same author, page 22: "Genus *Clathria*—Desmacidonidæ with a skeleton composed of bundles of spicules invested by spongin, from which spined styli protrude." One of Lendenfeld's species of *Clathria* has chelæ (*C. pyramida*) and two have no chelæ, (*C. macropora* and *C. australis*). Therefore up to now there are four species of *Clathria* without chelæ, viz., *C. australis*, *C. inanchorata*, *C. macropora*, and *C. seriata*.

The living sponge is of a dark blood-red colour, and encrusts the rocks with a layer of about 3 mm. in thickness. The skeleton consists of a network of horny fibres 0·016—0·028 mm. thick. The meshes are square, and 0·09—0·225 mm. wide. In the axis of the horny fibres, as well as echinating from the fibres, smooth styli are found, 0·1 mm. by 0·008 mm. The echinating styli generally stand together in bundles, and spring from the points where the fibres meet. According to Bowerbank toxa are very abundant in this species, but I found comparatively few of them. They measure 0·05 mm. by 0·001 mm.

The oscula are numerous, and 1 to 1·5 mm. in diameter.

As I mention on page 208, this species is frequently found along with *Plumohalichondria atrasanguinea*, B. As these two species agree completely in colour, and as *Pl. atrasanguinea* is decidedly the form which is best defended by the spicules, it might be regarded as a case of mimicry. The bright colouring of *Pl. atrasanguinea* would then be warning, and that of *Clathria seriata* protective. The similarity in colour may, however, be quite accidental.

Plumohalichondria atrasanguinea, Bowerbank.

Microciona atrasanguinea, Bowerbank.

This form is new to our district, another species of the same genus, *Plumohalichondria plumosa*, Carter, having previously been obtained at Holyhead.* I found it at Puffin Island, April, 1889, and at Hilbre Island, May 1889, a short way above low-water mark.

Bowerbank † records it from St. Katherine's Cave, Tenby; rocks off Hastings; Guliot Caves, Sark; Lennen Cove, Land's End, Cornwall, and he describes the external appearance of this sponge in the following words:—" Its appearance is that of a small patch from one to two inches in diameter, of dark clot of blood adhering closely to the surface of the rock, and it can be obtained only by cutting away the piece of stone to which it adheres. It rarely exceeds about half a line in thickness. Its extreme thinness readily distinguishes it from the deep red coloured sponge, *Chalina seriata*,§ which occurs abundantly along with it in that cave (at St. Katherine's Island, Tenby), and which is so thick as to be easily removed from the rock with a knife." Bowerbank's description applies very well to the condition in which I found this form, together with *Clathria seriata*, at Puffin Island. In order to get sections of *Plumohalichondria atrasanguinea* one has to remove a portion of the rock (carbonate of lime) together with the sponge, and dissolve the former with acids. Specimens from Hilbre Island are of less use for histological purposes because the rocks there consist of sandstone.

The ceratose skeleton of our species consists of a limiting membrane which is closely applied to the rock, and of ascending fibres, arising about at right angles from the limiting membrane. Those fibres are furnished abundantly with echinating megascleres of two kinds; there are styli

* Thomas Higgin, "Report on the Porifera," in "Fauna of Liverpool Bay," p. 78.

† Bowerbank, "British Spongiadæ," vol. ii,, p. 139.

§ *Chalina seriata* is identical with *Clathria seriata*, see p. 205.

(0·3—0·53 mm. by 0·012 mm.) and spined styli (0·148 mm. by 0·008 mm). The former generally spring from the inner portions of the fibres, and at less acute angles (about 25°), whilst the spined styli have their bases more in the outer portions of the fibres and spring at greater angles (about 50°) from the fibres. There are also two kinds of microscleres—toxa (0·124 mm. by 0·002 mm.) and extremely minute chelæ (0·012 to 0·016 mm). The microscleres are irregularly scattered through the tissue between the ascending fibres.

A very brief description of this species has also been given by Carter.*

Axinella mammillata, n. sp. (Pl. X., figs 3—5).

I was doubtful for some time in which genus of the family Axinellidæ, the new sponge described below, should be included. At first I was rather inclined to make of it a new species of *Raspailia*, Nardo, but as Ridley and Dendy † propose to reserve the genus *Raspailia* exclusively for the whip-like forms, I decided to place the new sponge under the genus *Axinella*, Schmidt.‡ Still in doing so I do not feel great satisfaction, as the genus *Axinella* seems at present to be a receptacle for all Axinellidæ which do not belong to the more clearly defined genera: *Hymeniacidon, Phakellia, Ciocalypta, Acanthella, Raspailia, Dendropsis*, and *Thrinacophora*. Ridley and Dendy say, in regard to the genus *Axinella*, "Sponge typically ramose, but may be massive. Skeleton fibre plumose. Megasclera stylote and sometimes oxeote. No microsclera. This is a very critical genus, and it is impossible to give a satisfactory

* Carter, "Annals and Mag. Nat. Hist.," fourth ser., vol. xvi., p. 195, and fifth ser., vol. vi., p. 40.

† Ridley and Dendy, "Report on the Monaxonida, collected by H.M.S. 'Challenger,'" p. 178 and p. 188.

‡ Oscar Schmidt, "Spongien des Adriatischen Meeres." 1862, p. 60.

diagnosis of it. It comes very near to *Raspailia*, but the latter is conveniently kept distinct on account of its very characteristic whip-like external form." Consequently the genus *Axinella* seems to fulfill a similar function amongst the *Axinellidæ* to that of *Amphilectus*, Vosmaer amongst the Desmacidonidæ.

Externally and in colour, *Axinella mammillata*, n. sp., has very much the appearance of *Polymastia mammillaris*, J. It consists of a basal mass with papillæ arising from it. The basal mass measures 22 mm. by 16 mm. horizontally and 8 mm. vertically. There are about thirty papillæ on the specimen, with a length of 1 to 8 mm. and 1 to 1·5 mm. in thickness. Generally we find two or three papillæ springing from a common origin. The colour is orange, with exactly the same tint as *Raspailia rigida*, M.

The skeleton consists only of megasclera, and these are styli of two different sizes, the one kind measuring 0·5 mm. by 0·008 mm., and the other kind 0·15 mm. by 0·004 mm. Inside the papillæ the longer styli are packed together in bundles which run parallel to the longitudinal axis of the papillæ. The shorter styli do not form bundles, they stand at right angles to the longitudinal axis of the papillæ, and project for about half their length through the ectoderm. Some of the styli show a slight swelling on their broader end and approach tylostylote character.

Ceratose is present in this species, but only in very small amount. It is found near the base of the bundles of the large styli.

Interesting are certain spindle-shaped granular cells (see Pl. X, figs. 4 and 5) of the mesoderm, measuring about 0·018 mm. by 0.003 mm. Their nucleus is small, and often only indistinctly seen. These cells are aggregated together in strands, and are found in the immediate neighbourhood of the longitudinal bundles of styli, and running parallel to them. Their chief character is: they are filled up by strongly light-refracting clear granules, the diameter of which I estimate to be 0·0006 mm. From their position and appearance I scarcely doubt that those cells are the skeleton-forming elements (scleroblasts), and the appearance suggests that these granules represent anabolic stages in the formation of the siliceous material for building up the spicules. However, developing spicules were never seen inside those cells.

Apparently the same structures have been figured by Oscar Schmidt * in *Halisarca guttula*, S., *Spongia adriatica*, S., and *Spongelia elegans*, S. He describes them as irregular, mostly spindle-shaped bands of sarcode, with delicate processes, full of molecular granules, but without cell membrane, nucleus or nucleolus. He gives the following resumé about the nature of these structures: "Die sehr allgemein bei den Spongien vorkommenden Körnerballen, welche oft regelmässig und dicht geschichtet erscheinen und nicht selten mit einem helleren Centralfleck versehen sind, sind weder nach ihrer Entstehung noch nach ihren Bestandtheilen als gemeine Zellen aufzufassen. Sie sind ein Product oder Derivat der Sarcode, und da ich die Körnchen bei keinem Schwamme vermisste, ein mehr oder weniger wesentlicher Bestandtheil dieser Substanz." Notwithstanding Schmidt's views I cannot help regarding those structures as true cells. To call them "Product oder Derivat der Sarcode" is no satisfactory explanation from the standpoint of modern histology.

Similar cells have been figured by Ridley and Dendy † in *Axinella* (?) *paradoxa*, which in the explanation of the

* Oscar Schmidt, "Supplement der Spongien des Adriatischen Meere enthaltend Histologie," &c,, p 3, pl. i., figs. 6—11.

† Ridley and Dendy, "Report on the Monaxonida, collected by H.M.S 'Challenger,'" pl. xlix., fig. 2a.

plate are called "portion of a band of elongated mesodermal cells found accompanying a skeleton fibre."

I have mentioned already the great similarity which exists in the external appearance of *Axinella mammillata* and *Polymastia mammillaris*. As it might be misleading to distinguish the species by the spicules alone, as those of *Axinella mammillata* sometimes approach the tylostylote character, and those of *Polymastia mammillaris* the tylote character, it appeared quite necessary to sectionize one of the papillæ for the sake of identification. The difference then is quite striking. In *Polymastia mammillaris* the papilla has the form of a tube with a large central cavity, with large subdermal spaces and well developed pore-membranes.* None of these characters are present in *Axinella mammillata*. Inside of the papillæ we have here and there larger or smaller quite irregular cavities, no distinct subdermal spaces, and of oscula, pores and pore-membranes nothing definite could be seen.

I found one specimen of this new species in one of the tidal pools on the north end of Puffin Island, at lowest tide, April, 1889.

Raspailia ventilabrum, Bowerbank.

Dictyocylindrus ventilabrum, Bowerbank.

In my previous report I regarded this species as identical with *Raspailia viminalis*, Schmidt, and described it under that name. But, as pointed out recently by Topsent,† there exists a difference between *R. viminalis*, S., and *R. ventilabrum*, B. The styli are slightly tylostylote in *R. viminalis*, whilst in *R. ventilabrum* they are of the normal character.

* See my former Report in Proc. Liverpool Biol. Society, vol. iii., pl. vi., figs. 2 and 3.

† Emile Topsent, "Etudes de Spongiaires." Revue Biologique du Nord de la France, tome ii., no. 8, Mai, 1890.

A single specimen had previously been recorded from Church Bay, near Holyhead. On the "Hyæna" expedition of May 25th, 1890, we dredged three specimens in Penrhos Bay (10 fathoms) and off Rhoscolyn Beacon (12 fathoms), on the west coast of Anglesea. The best of the specimens showed a narrow base with four branches, three of which were again divided dichotomously. The colour was a dull purple. The height of the specimens ranges between 4 and 6 cm. Their branches are perfectly cylindrical, whilst Bowerbank's * figure shows rugged ridges along the branches. Probably Bowerbank's figure is not quite reliable, as it had been taken from a dried specimen.

Raspailia rigida, Montagu.

Spongia rigida, Montagu, Mem. Wern. Soc., vol. ii., pt. i.

Non *Raspailia (?) rigida*, Ridley and Dendy, Chall. Rep., p. 191.

The species, which in my former report I regarded as *Raspailia stelligera*, Schmidt, seems in reality to be *Raspailia rigida*, Montagu. Topsent's † recent paper has drawn my attention to this fact. There are two species of the genus *Raspailia*, Nardo, which possess stellate spicules, both first described by Montagu under the names *Spongia stuposa* and *Spongia rigida*, the latter differing from the former by having much shorter branches and larger stellate spicules. Bowerbank considered the *Sp. rigida* merely as a dwarfed variety of *Sp. stuposa*, and included both in the name *Dictyocylindrus stuposus*. But Topsent shows that they are really distinct species. Consequently as my specimens have very short branches indeed and comparatively large stellate spicules, I consider them to be *Raspailia rigida*, M. As stated by Topsent, the *Ras-*

* Bowerbank, loc. cit , vol. iii., pl. xvi.

† Emile Topsent, loc. cit.

pailia stelligera, Schmidt, is only a superfluous synonym for *Raspailia stuposa*, Montagu.

There are, as mentioned above, two species of *Raspailia* with stellate microscleres, *R. stuposa*, M., and *R. rigida*, M. In my former report I drew attention to Ridley and Dendy's statement that the only stellate forms of microscleres "which are certainly known to occur in the Monaxonida" are spirulæ, discastra and amphiastra," and I proposed that spherasters should be mentioned as a fourth form of stellate microscleres in the Monaxonida, and that the limits of the genus *Raspailia*, as given by Ridley and Dendy, should be enlarged by leaving out the negative character "no microsclera," so as to reconstitute the older and wider genus defined by Nardo and Schmidt. I see now that Lendenfeld's definitions of the group in question also want alterations. In his "Descriptive Catalogue"* the definition of the order "Cornacuspongiæ," which comprises also the Axinellidæ, is too narrow, as it gives the negative character "Microsclera, never stellate." This character should be left out. Similarly in the "Monograph†" Lendenfeld defines his sub-family "Axinellinæ," which includes *Raspailia*, as "Axinellidæ without microsclera." This definition also wants correction.

This species which has now been found on the shores of Puffin Island several times, has also been dredged on the "Hyæna" expedition of May 25th, 1890, in Penrhos Bay, west coast of Anglesey, from a depth of about 10 fathoms.

Suberites domuncula, Nardo.

Halichondria suberea, Montagu.

Johnston‡ describes this sponge under the name *Hali-*

* R. v. Lendenfeld, "Descriptive Catalogue of the Sponges in the Australian Museum, Sydney," p. 74.

† R. v. Lendenfeld, "A Monograph of the Horny Sponges," p. 903.

‡ Johnston, "British Sponges," p. 140.

chondria suburea, and says, in regard to its habitat, "It has the singular property of being attached only (so far as I have been able to ascertain) to old univalve shells, which it entirely invests." He mentions then that most of those shells were inhabited by hermit-crabs. Schmidt's* definition is similar, "Suberites globosus, incrustans et involvens conchas, quas Paguri domos sibi elegerunt." Mr. Higgin has already recorded specimens of this peculiar habit from Holyhead and Morecambe Bay, and I am able to add Calf of Man, where it was dredged on the "Hyæna" expedition of April, 1889. But still this species does not seem to restrict itself exclusively to univalve shells inhabited by hermit-crabs, although those cases are the conspicuous and interesting ones. A sponge, apparently of the same species, was dredged on the above mentioned "Hyæna" expedition of April, 1889, and also off Calf of Man. It encrusted a living *Pecten opercularis*, forming a thin layer (about 2 mm. in thickness) of greyish colour. I have found it also encrusting tetractinellid sponges, on *Seiriola compacta*, mihi, and on *Stelletta collingsi*, B. As I shall state more fully on page 221, I erroneously described in my former report such an encrusting layer of *Suberites domuncula* as the ectosome of *Seiriola*. The upper portion of fig. 1, Pl. VII., Vol. III., Proc. Liverpool Biol. Soc. may therefore be taken as a fairly correct representation of a vertical section through a *Suberites domuncula*. The thickness of that specimen was unusually small, only about 0·24 mm. The spicules of it are tylostyli 0·1 to 0·38 mm. by 0·003 to 0·006 mm. They are arranged in bundles, and project for about one-half of their length through the ectoderm. The heads of the longer tylostyli are supported by the basal membrane. The figure also

* Oscar Schmidt, "Spongien des Adriatischen Meeres," Theil i., p. 67.

shows pore-membranes, pores and sub-dermal cavities.

Suberites ficus, Esper.

Alcyonium ficus, Esper.
Halichondria ficus, Johnston.
Hymeniacidon ficus, Bowerb., B. S., vol. ii., p. 206 ; vol. iii., pl. xxxvi.
Halichondria ficus, Carter, A.M.N.H., 5, ix., p. 353.
Suberites ficus, Schmidt, Spongienfauna des Atlant. Gebietes, p. 76.

Two specimens of this species were found by Mr. Herbert C. Chadwick opposite the ferry-slip, at Bangor, in August, 1887, attached to the rock. I was unable to record it in my former Report, as I heard only quite recently about this find. The one specimen is about 3 cm. in height, the other one 1·3 cm. This species has been recorded by Bowerbank from the coast of Scotland ; coast of Northumberland; Island of Harris; Hebrides; and from Gilter Sound, near Tenby. I may mention that about fifteen fine specimens of *Suberites ficus* were dredged by Professor Herdman in the Sound of Mull, in 1881, and are now in the Zoological Museum of University College, Liverpool.

Cliona celata, Grant. (Pl. XI., fig. 2, and Pl. XII).

Vioa celata, Nardo.
Spongia terebrans, Duvernoy.
Halichondria celata, Johnston.
Hymeniacidon celata, Bowerbank.
Raphyrus Griffithsii, Bowerbank.
Vioa celata, O. Schmidt.
Papillina suburea, O. Schmidt.
Spongia sulphurea, Desor.
Cliona sulphurea, Verill.

Mr. Higgin, in his "Report on the Porifera of the L.M.B.C. District," page 85, has already mentioned that in our district both forms of *Cliona celata* are found, the "massive" and the "sinuous" one, but I am not aware that massive specimens of such a size were ever found before in our neighbourhood as those which were dredged on the "Hyæna" expedition of May 25th, 1890, on the west coast of Anglesey. The first specimen was got in Penrhos Bay, from a depth of about ten fathoms. More material was taken off Towyn (twelve fathoms), and lastly off Rhoscolyn Beacon (twelve fathoms) the dredge brought up a specimen larger than any sponge ever found in our district, and probably not exceeded in size by any sponge ever collected on the British coast. It measures horizontally 31 cm. by 20 cm., and vertically 12 cm. The figure on Pl. XII. represents the specimen in not quite one-half natural size. I drew it from a photograph which Mr. Benjamin Davies (Physical Laboratories, University College, Liverpool) had kindly taken from the specimen after it had been in spirit for some time. Those members of our expedition who attempted to photograph it on board of the "Hyæna" were less successful.

The colour of the largest and of most of the smaller specimens, when alive, was ochreous-yellow. But the first specimen which we got from Penrhos Bay, was distinctly sulphur-yellow. The oscula are large and well marked. They have the shape of slits, and measure from 2 by 1 mm. to 8 by 3 mm. Two of them are seen in the figure upon one of the smaller lobes. A row of oscula on the upper edge of the largest lobe could not be represented in the figure. The pore-areas form extremely numerous and well-marked circular patches (2 mm. in diameter) on the extremity of very short papillæ, just projecting beyond the level of the sponge. In the "sinuous" form of *Cliona celata* those little papillæ with their pore-areas are generally the only things which are visible inside of or projecting from the small circular holes of the inhabited and perforated shell.

The spicules are tylostyli. They measure 0·315 mm. by 0·008 mm. A few of them were smaller, down to 0·225 by 0·003 mm. A vertical section through the sponge shows at the first glance two very different tissues. The one is strong, fibrous and full of spicules, the other one is highly porous and reticulated, with a smaller number of spicules. The latter chiefly forms the choanosome, the former the ectosome, but broad strands of the ectosome are given off, which project down and branch throughout the choanosome, thus giving a strong support to the soft tissue of the choanosome (Pl. XI., fig. 2). The incurrent and excurrent canals are large and numerous. The size of the flagellated chambers is about 0·04 by 0·028 mm.

If one sees only the two extremes in the mode of growth of *Cliona celata*, the small boring form, which scarcely projects out of the holes of a perforated oyster shell, and the large massive form described above, then it is really difficult to convince oneself of the identity of the two forms. Intermediate stages, however, soon show the identity. The Zoological Museum of University College, Liverpool, possesses a specimen, dredged by Professor Herdman in Cailliach Bay, Mull, September, 1882, which represents an exceedingly good example of such an intermediate stage. The pore-areas of the future massive form are all fully developed, but they are easily recognized as being the upper surfaces of small papillæ which project from the holes of the perforated foreign body. Further, there is a layer of sponge-mass (varying from 1 to 3 mm. in thickness) outside and above the non-perforated surface of the foreign body (an igneous rock), which layer extends laterally to and fuses with the papillæ.

After the boring form of *Cliona celata* had been described by Grant and Nardo, Johnston discovered the massive stage and recognized it as a variety of the boring one. Other authors again considered both forms as different species, so also Bowerbank, who established a new genus for the massive form and called it *Raphyrus Griffith-*

*sii.** For an exhausting account of this comedy of errors I refer to Leidy's recent paper "The Boring-Sponge, *Cliona* †"

Leidy, in his paper, also discusses the question whether the *Cliona sulphurea*, Desor, of the American coast, which is found both boring and massive, might be identical with *Cliona celata*, Grant, of Europe. He finds that the two forms agree in all respects except two. Hancock ‡ had stated that in *Cliona celata*, Grant, hexagonal siliceous granules are found on the surface of the sponge, by which the latter is able to work out the cavities it inhabits. Leidy says he has not been able to detect those granules in the American sponge. The second difficulty is : "Grant, Hancock, Bowerbank, and Lieberkühn give as the size of the spicules of *Cliona celata* about $\frac{1}{50}$ of an inch, while in all our ('i.e. American') forms of *Cliona*, in the oyster and clam, and in the largest massive varieties, the size of the spicules is only about $\frac{1}{80}$ of an inch."

The first difficulty about the hexagonal granules has been solved by Topsent.§ He considers them as broken pieces of the prismatic layer of the perforated shell, perhaps intermixed with grains of quartz. In regard to the second difficulty, Topsent remarks that the difference in size of spicules cannot be of much value, as he himself has observed spicules from 0·18 mm. to 0·35 mm. in length. On page 217 I gave as the length of the spicules 0·315 mm. As $\frac{1}{50}$ inch is equal to 0·508 mm., and $\frac{1}{80}$ inch is equal to 0·317 mm., we see that Topsent's and my own observations agree with Leidy's measurements as exactly as one could expect,

* Bowerbank, "British Spongiadæ," vol. ii., p. 354 ; vol. iii., pl. lxiv.

† In. "Pro. Acad. Nat. Sciences, Philadelphia," part i., January—April, 1889, p. 70.

‡ Albany Hancock, "On the excavating power of certain Sponges belonging to the genus Cliona," 1849.

§ Emile Topsent, "*Cliona celata* ou *Cliona sulphurea ?* Bulletin de la Société Zoologique de France," 1889, p. 351.

whilst we all three differ from the older and perhaps incorrect observations. There can be no doubt whatever that *Cliona sulphurea*, Desor, *is* identical with *Cliona celata*, Grant. I will add that I have measured also the spicules of a boring form of *Cliona celata* from Puffin Island, and get the following results: most spicules about 0·36 by 0·008 mm., a few smaller down to 0·27 by 0·003 mm.

Polymastia mammillaris, Johnston.

Several specimens of this were dredged on the "Hyæna" expedition of May 25th, 1890, in Penrhos Bay (10 fathoms), off Rhoscolyn Beacon (12 fathoms), and off Porth Dafarth, Anglesey. The largest of the specimens forms a globular mass with a diameter of 4 cm. More than one hundred papillæ rise from its upper surface. The other specimens were slightly smaller and flatter. They all were of a bright orange-yellow. One small specimen was also collected at the east end of Puffin Island, June 18th, 1890. This species had previously been dredged in Church Bay, near Holyhead. For description and figures see my former report.

Polymastia robusta, Bowerbank.

In my former report I recorded this species from Church Bay, Holyhead. We have dredged since two specimens of it on the "Hyæna" expedition of May 25th, 1890, in Penrhos Bay (10 fathoms), and off Rhoscolyn Beacon (12 fathoms), on the west coast of Anglesey. The specimens are hemispherical masses, of a diameter of about 4·5 cm. in horizontal direction and 2 cm. in height. The colour of the one specimen was a dirty greyish-yellow; of the other one a pure orange tint.

Order IV. **TETRACTINELLIDA.**

Tethya lyncurium, Johnston.

Five specimens of almost perfect globular form were dredged on the "Hyæna" expedition of May 25th, 1890, in Penrhos Bay (10 fathoms), and off Rhoscolyn Beacon (12 fathoms), on the west coast of Anglesey. The cortex of the living sponge was cadmium-yellow, its inner portion brown. The diameter of the specimens is 1·5 to 2 cm. One of them was covered with about thirty buds.*

One specimen of this species had previously been dredged in Church Bay, Holyhead.

Dercitus bucklandi, Bowerbank.

This sponge, which had already been recorded by Mr. Higgin under the name *Dercitus niger*, C., from Holyhead, has now also been discovered at Puffin Island. I found a few specimens of it at the entrance of the large cave on the north end of the island, at low spring tide, April, 1889. The largest of the specimens measures 3 cm. by 2 cm. in horizontal direction and 0·6 cm. in height. Colour, dark black.

For an extensive list of the literature, and a revised description of this species, see Sollas.†

Seiriola compacta, Hanitsch (Pl. XIII., figs. 1—4).

In my former report on the Porifera of the L.M.B.C. District ‡ I described and figured a new species of a tetractinellid sponge under the above name, which I took to be the representative of a new family. But in doing so I fell into a serious error, and I have to thank Professor Sollas, D.Sc., for pointing out the mistake to me. The two layers which I described as ectosome and choanosome of *one* sponge are really two quite separate sponges, an encrusting Suberite and an encrusted Stellettid. "Each is," as Prof. Sollas writes me, after having seen my preparations, "a separate individual, the Suberite is defined from the

* Compare Bowerbank, "British Spongiadæ," vol. ii. p. 94.

† Sollas, "Report on the Tetractinellida collected by H.M.S. 'Challenger,'" p. 108.

‡ Proc. Liverpool Biological Society, vol. iii., p. 169—172, pl. vii.

Stellettid by its own basal membrane, and the Stellettid from the Suberite by its outer epithelium, distinguished in favourable parts of the sections by the somewhat dense layer of sanidasters which usually are more crowded there than elsewhere. The basal membrane of the Suberite supports the heads of the longer tylostyles as so commonly happens in these sponges." Curiously enough Döderlein * fell into a quite similar error in regard to *Discodermia calyx*, D., and Bowerbank † in regard to *Stelletta collingsi*, B., and *Stelletta schmidtei*, B. As, notwithstanding the above stated error, the encrusted tetractinellid sponge is new to science, and is the only representative of a new genus, *Seiriola*,‡ I propose to give now a corrected description of it. No new figure of the spicules will be necessary, as I can refer to Vol. III., Pl. VII., where, however, no notice should be taken of the upper thinner layer which does not belong to *Seiriola compacta*. This foreign layer is characterized by tylostylote spicules and is separated from the lower portion, the *Seiriola compacta*, by a definite line of demarcation. It belongs to a monaxonid sponge, *Suberites domuncula*, Nardo.

The first specimen of *Seiriola compacta* was found at Puffin Island, in June, 1888, in one of the caves on the north-east side of the island, which are exposed only at low spring tides, and then accessible only by boat. It formed a knob-like mass, like that of so many tetractinellid sponges, and measured horizontally 4 cm. by 1·5 cm., and vertically 1·3 cm. It came into my hands after it had been in rather weak spirit for several weeks, and was then

* Sollas, "Report on the Tetractinellida," collected by H.M.S. "Challenger," p. 295.

† Sollas, loc. cit., p. 186.

‡ From Seiriol, an early Welsh saint, who is said to have had his cell on Puffin Island.

of dark grey colour. In April, 1889, I collected in the same cave several specimens of *Seiriola* which were white with a slight greyish tint, and have kept their colour perfectly well in strong spirit. The specimens have about the same dimensions as the original one, but they are flatter. Although the shape and colour of this sponge agree completely with those of *Stelletta collingsi*, B., which I collected at the same time and in the same locality, still one may distinguish the two forms in the following way: *Stelletta* has a hispid surface; *Seiriola* is smooth to the touch; *Stelletta* shows a cortex even in a rough vertical section made with the pocket-knife; *Seiriola* does not. Curiously also a specimen of the new material was encrusted by *Suberites domuncula*, and in the same way also one or two specimens of *Stelletta collingsi*. The rest were not encrusted. Oscula and pores were not visible in the living specimens.

The skeleton of *Seiriola compacta* consists of megascleres and microscleres. The former show the following forms: dichotriæna, orthotriæna, oxea, styli, strongyla, tylota. The dichotriæna are very numerous, and are arranged immediately beneath the surface, with their cladomes directed towards the surface. The rhabdome measures from 0·36 to 0·42 mm., the protocladus from 0·06 to 0·09 mm., and the deuterocladus from 0·037 to 0·45 mm. The orthotriæna are far less numerous and slightly smaller than the dichotriæna. They are also placed close to the surface. The oxea are the most numerous spicules, and are arranged in bundles, which take their origin in or immediately beneath the region of the triæna, and stretch vertically down through the whole depth of the sponge. The oxea measure 0·34 to 1·5 mm. by 0·009 to 0·026 mm. Amongst them we find a few stylote, strongylote, and tylote spicules.

The microscleres are oxyasters, 0·025 mm. in diameter, and sanidasters (not spirasters, as I called them in my previous report) 0·012 to 0·016 mm. in length, and are both very typical forms. The oxyasters are found only in the choanosome, the sanidasters chiefly in the ectosome, and a few also in the choanosome.

Besides those megascleres and microscleres, I found fragments of a third kind of spicule (see fig. 2 c., Pl. VII., Vol. III.), the appearance of which, in my former report, I compared with broken blades of fret saws. The largest of these pieces measured 0·08 by 0·0014 mm. They were found just beneath the surface of the sponge. But now I think it quite possible that they do not belong to *Seiriola* at all, but rather to *Stelletta collingsi*, in which latter sponge I now describe them for the first time (see Pl. XIV., figs. 1 and 2). As my specimens of *Seiriola* and *Stelletta* had been taken from the same rock, and had been kept together for some time in the same jar of spirits, it is possible that fragments of those spicules found their way accidentally into the *Seiriola*.

Oscula and pores could not be distinctly seen, neither in the living specimens nor in sections. The incurrent and excurrent canals seem to branch in a very irregular manner through the sponge. The chamber-system appears to belong to the eurypylous type,* in so far as the flagellated chambers lie closely round the excurrent canals, and as the apopyles are not continued into special tubes and are extremely short. At the same time the term "eurypylous" does not apply correctly to *Seiriola*, as the apopyles are extremely narrow. The flagellated chambers and collar cells are very small. The former are oval, and measure 0·012 by 0·008 mm. The collar cells measure 0·0013 mm.

The mesoderm of *Seiriola* consists of sarcenchym, the

* Sollas, loc. cit., p. xv.

greatest part of which however has been replaced by cystenchymatous tissue, also called vesicular connective tissue or bladder-cells ("blasiges Bindegewebe" of German authors). These bladder-cells are generally spherical, with an average diameter of 0·04 mm. In the original, less well preserved material of *Seiriola*, these cells contained very little protoplasm which, together with the small nucleus, adhered to one side of the cell-wall only, leaving the greatest part of the cell quite empty (compare Pl. VII., fig. 1, Proc. L'pool Biol. Soc., Vol. III). Also in the second and well preserved material the bladder cells showed eccentrically situated nuclei; the protoplasm, however, was found not only round the nuclei and along the neighbouring parts of the cell-wall, but threads of it radiated throughout the remainder of the cell (Pl. XIII., figs. 1 and 2). Bladder-cells have been already observed by various authors in other sponges, as by Vosmaer* in *Polymastia hemisphærica*, by Sollas† in *Pachymatisma*, *Stryphnus*, &c., and also in some of the Lithistida. A similar tissue is known to occur in many Molluscs and in Tunicata.‡

Of great interest too were strands of spindle-shaped cells which occur in great frequency (Pl. XIII., figs. 1—3). The cells are arranged longitudinally and in parallel rows, and are apparently imbedded in a clear gelatinous matrix. Their size varies greatly, the largest cells measure about 0·048 by 0·014 mm. Both ends of the cells are prolonged into delicate fibres. They are all highly granular, and intensely stained after treatment with picro-carmine. The

* Vosmaer, "Sponges of the 'Willem Barents Expedition, 1880 and 1881," in "Bijdragen tot de Dierkunde."

† Sollas, "Report on the Tetractinellida," collected by H.M.S. "Challenger," p. xxxix.

‡ W. A. Herdman, "Report on the Tunicata," collected by H.M.S. "Challenger," Vol. I., pp. 28—29.

nuclei are small and not very conspicuous, apparently on account of the opaque protoplasm of the cells. The nature of these cells seems to be distinctly different from that of the much smaller spindle-shaped cells described in *Axinella mammillata*, n. sp. (page 211). In the latter species the granules of the cells are distinctly spherical, clear, and highly light-refracting. In *Seiriola* the granules are opaque, and apparently of no definite outline. Further, in *Axinella* the spindle-cells run in strands along the chief masses of spicules, and suggest at once that they might be "scleroblasts." But in *Seiriola* such a relation between the spindle-cells and the spicules does not seem to exist. On the contrary, quite independently of the presence or absence of spicules, the strands of those cells permeate the choanosome in an irregular fashion, giving off numerous branches (Pl. XIII., fig. 3). Further, I have not been able to find any connection between those strands and the incurrent and excurrent canals, or with any other structure. Transverse sections through the strands are frequently met with in preparations, and they show a round outline. Sollas's "myocytes" seem to be similar structures, but they differ from those cells in *Seiriola* by chiefly occurring "concentrically arranged about the openings of the water-canals." Still I shall not be surprised if future investigations prove those cells to be neuro-muscular elements.

In regard to the systematic position of *Seiriola compacta* Professor Sollas wrote me as follows:—"The choanosomal spicule is a characteristic oxyaster, the ectosomal microsclere is a typical sanidaster; this latter places the sponge in the Sanidasterina. Of the genera of this group it approaches most nearly *Stryphnus*, but differs from all the species of this genus which I have seen. The sanidaster is a better sanidaster, i.e., more typical and regular than in most species of *Stryphnus*, and the oxeas are not colossals, while they do seem to be arranged in bundles." Prof. Sollas further suggested placing *Seiriola compacta* as a new species of the genus *Stryphnus*, Sollas.*

In consequence of Prof. Sollas's advice I have now decided to drop the new family "Seiriolidæ" which I established in my former report, and I place the new sponge amongst the Sanidasterina, a sub-family of the family Stellettidæ. But I still intend to retain the new genus "*Seiriola*." The differences between it and the genus *Stryphnus* justify, I think, my doing so. These differences are :—

(1.) *Stryphnus*—The choanosomal megascleres are colossal oxeas, closely strewn through the sponge, not aggregated to form fibres and not radiately arranged. *Seiriola*—The choanosomal megascleres are oxeas of ordinary size, and besides those also styli, strongyla and tylota. The spicules seem to be aggregated in bundles, and somewhat radiately arranged.

(2.) *Stryphnus*—The microscleres are some form of euaster, and an irregular amphiaster or sanidaster. *Seiriola*—The microscleres are typical forms of oxyaster and sanidaster.

(3.) *Stryphnus*—The flagellated chambers are either aphodal or slightly diplodal. *Seiriola*—The flagellated chambers are eurypylous.

Stelletta collingsi, Bowerbank (Pl. XIV., figs. 1—3).

Tethea collingsii, Bowerbank.
Tethea schmidtei, Bowerbank.
Collingsia sarniensis, Gray.
Collingsia schmidtei, Gray.
Stelletta collingsii, Sollas.

The sponge, which in my former report was mentioned

* Sollas, loc. cit., p. 171.

under the name *Ecionemia ponderosa*, B., has, by further examination, turned out to be a *Stelletta collingsi*, B., or at least a variety of it.

I have found in it all the different kinds of spicules which have been mentioned by Bowerbank, and more recently by Sollas,* and some other spicules in addition to those. The megascleres are—oxea 1·8 by 0·032 mm.; orthotriæna, the rhabdome of which measures 1·42 by 0·032 mm., and the cladi 0·105 by 0·028 mm.; a few dichotriæna, the protocladi of which measure in length 0·056 to 0·084 mm., and the deuterocladi 0·028 to 0·046 mm.; and a very few protriæna, rhabdome 0·40 mm., cladi 0·036 mm. Both dichotriæna and protriæna had not been mentioned by previous authors. The microscleres are—chiaster, 0·012 mm. in diameter, found only in the ectosome, just beneath the surface; and oxyasters with a varying number of actines, found chiefly in the choanosome. It seems to be the rule that the larger the oxyasters are, the smaller is the number of their actines. I found that—

4	radiated oxyasters	measured	0·056	mm.	in diameter
6	,,	,,	0·040	,,	,,
8	,,	,,	0·032	,,	,,

Besides those above-mentioned kinds of megascleres and microscleres I found an additional kind of spicule which I will call "prionorrhabds" † (Pl. XIV., figs. 1 and 2). They are long and slender spicules, 0·40 by 0·002 mm., one end of which is profusely spined, the other and larger portion is smooth. The two extreme ends of the spicules are sharply pointed. I have found these prionorrhabds only in the ectosome, with their spined ends imbedded in it and the smooth ends projecting through the ectoderm and penetrating into a calcareous sponge *Sycan-*

* Sollas, loc. cit., p. 185.

† From πρίων a saw.

dra ciliata, which was attached to the surface of the *Stelletta*. The prionorrhabds are arranged radiately, the ideal centre of the circle lying inside the *Sycandra*. But only this one small portion of the *Stelletta*, opposite to which the *Sycandra* is situated, shows those spicules.

As this special kind of spicule has never before been described in *Stelletta collingsi*, nor in any other sponge, the question arises whether my specimen is identical at all with *St. collingsi* or whether the spicules are present in all specimens of *St. collingsi* and have been overlooked by former investigators, or lastly, whether they are a special acquirement which may become developed in the sponge under certain conditions. I am inclined to accept the last of the three views. I have mentioned already that the prionorrhabds were found only in a certain portion of *Stelletta*, and I believe that they have been acquired by the sponge under the special abnormal conditions to protect itself against the encroaching foreign body, a calcareous sponge. As in my specimen they are very localized, it is quite possible that they have been overlooked by other workers.

I collected several specimens of *Stelletta collingsi* at Puffin Island, in one of the caves on the north end of the island, in April, 1889. One specimen had been found there already, in June, 1888. The colour of the living specimen is greyish-white.

Pachymatisma johnstonia, Bowerbank.

The colour of this species is known to be subject to great variation. Bowerbank* states—"Littoral specimens, light to dark slate-grey. Deep sea specimens, pink or red." And Sollas† says—"Slate-grey on the portion exposed to the light, almost white beneath; specimens from

* Bowerbank, "British Spongiadæ," vol. ii., p. 51.

† Sollas, "Report on the Tetractinellida," collected by H.M.S. "Challenger," p. 243.

considerable depths, pink or red (Bowerbank)." I had excellent opportunity of convincing myself of this variation in colour in one of the large caves at Puffin Island, in April, 1889. The cave, situated on the north end of the island, is accessible only at lowest spring tides, and even then only with boat. Right at the entrance to the cave I noticed that the specimens of *Pachymatisma* were of a dark slate-grey colour. Rowing further into the interior I found specimens of a light grey, and in the farthest recess of the cave I discovered some splendid specimens of a perfect cream-white tint. I found quite similar conditions in April, 1890, near Brada Head, Port Erin, in a cave which also is accessible only with boat and at lowest tide. The specimens of *Pachymatisma*, larger even than those at Puffin Island, were lighter in colour the further back in the cave they were found.

The explanation of these facts is, in my opinion, found only in the direct action of the light of the sun. The more exposed the specimens were to the light, the darker they were; the more protected, the lighter. I know very well that such an explanation is not at all in accordance with the generally accepted views, and Wallace's* statement, "that light and heat of the sun are not the direct causes of the colour of animals," is not only his own view, but is shared by the majority of modern biologists. Still my own view finds support in what Lendenfeld† has recently said in regard to the Ceratosa—"No differences are observed in the colour of different parts of the surface except that the lower side is generally lighter-coloured than the upper side. This is less of a protective acquisition than a direct effect of the light. The parts of the surface exposed to it are darker coloured by its photo-

* Wallace, "Darwinism," p. 195.

† R. v. Lendenfeld, "A Monograph of the Horny Sponges," p. 742.

graphic action than the lower side which is always in shade." I therefore merely apply what Lendenfeld said in regard to different parts of the same specimen to different specimens of the same species.

I will not omit to state that in neither of the two cases could one think of accounting for the colouring by protective resemblance to the environment. The lighter specimens especially were as different in colour from the rocks (carbonate of lime at Puffin Island and slate of Ordovician age at Brada Head, Port Erin) as they possibly could be. Altogether it has not been proved yet that sponges ever imitate their surroundings in colour. Out of the numerous species of our district which I have had occasion to examine in the living condition, not a single instance seemed to give a sure proof of such an imitation. If here or there a species of sponges, organisms which in their shades and tints show almost as innumerable transitions as the spectrum itself, happens to resemble its surroundings, whilst the vast majority of the other species do not, then it is surely out of place to take that one example as a proof of imitation of the environment. I may quote what Lendenfeld * says in regard to the Ceratosa—"The horny sponges never *imitate* their surroundings in colour, although some of them, particularly those which have an arenaceous cortex, are very similar in colour to the sea bottom on which they grow. Most of the horny sponges are, like many of the other shallow water Silicea, very intensely coloured, and it would appear that these vivid colours have been adopted by the sponges for the purpose of frightening their enemies." This seems really to be the only explanation for most of the colours in sponges. Animals which, like the great majority of sponges, are so extraordinarily well defended by their skeleton, are scarcely in need of a pro-

* R. v. Lendenfeld, "A Monograph of the Horny Sponges," p. 742.

tective colouring to enable them to escape from their enemies; what they really want are warning colours.

The dimensions of the largest specimen of *Pachymatisma* from Puffin Island is 10 cm. by 7 cm. in horizontal direction; 1·5 cm. in height. The largest specimen from Port Erin measures 12 cm. by 6 cm. horizontally and 6 cm. vertically. I give also the measurements of the spicules, as my results differ somewhat from Bowerbank's and Sollas's * :—

I.—Megasclera: strongyla, 0·57 to 0·75 mm. by 0·012 to 0·024 mm. Orthotriæna: rhabdome, 0·405 by 0·016 mm; cladus, 0·255 by 0·016 mm. Also a few styli are present, which are not mentioned by Bowerbank and Sollas. They measure 0·635 by 0·009 mm.

II.—Microsclera: sterraster, either spherical, 0·045 to 0·075 mm. in diameter; or elliptical, from 0·06 by 0·045 mm. to 0·09 by 0·068 mm. Oxyaster, 0·048 to 0·056 mm. n diameter; microstrongyla, 0·018 by 0·003 mm.

This species seems to be the only tetractinellid sponge which up to now has been found at the Isle of Man, and it is now for the first time recorded in our L.M.B.C. reports from that locality. I hear that Mr. Geo. Swainson, of Bolton, collected some specimens of it at Parwick Bay, Isle of Man, during last autumn.

Order VI. **CALCAREA.**

Ascetta coriacea, Fleming.

I found a single small specimen of this species at Puffin Island, April, 1889, at lowest spring tide, in the large cave on the north side of the island. It encrusted a living oyster, which latter was firmly attached to the wall of the cave.

* Sollas, loc. cit., p. 242.

Ascetta coriacea had previously been recorded from Port Erin and Holyhead, and I collected again great quantities of it at Fleshwick Bay, near Port Erin, Easter, 1890.

Ascaltis botryoides, Fleming.

A number of specimens of this form were obtained in Fleshwick Bay, near Port Erin, on the "Hyæna" expedition of Easter, 1889. I found them in a shallow pool just beyond the entrance of a long and narrow cave, where I collected some again at Easter, 1890. The level of the pool was near high-water mark (!).

Mr. Higgin records this species from Holyhead.

Ascaltis contorta, Bowerbank.

Leucosolenia contorta, B., Brit. Spong., vol. ii., p. 29 ; vol. iii., pl. iii.
Leucosolenia contorta, Carter, Midland Naturalist, vol. iii., p. 195.

A few small specimens have been found for the first time in our district by Mr. Herbert C. Chadwick, near Beaumaris, August, 1889, and subsequently I found it myself at Hilbre Island, March, 1890. Bowerbank records it from Guernsey, Scarborough (?), and from the Guliot Caves, Sark.

Ascortis lacunosa, Johnston.

Grantia lacunosa, Johnston.
Leucosolenia lacunosa, Bowerbank.

I refer to this species a few specimens which were dredged on the "Hyæna" expedition of May 25th, 1890, in Penrhos Bay, off Rhoscolyn Beacon, and off Porth Dafarth, where they were found sticking to Zoophytes. The presence of oxeote spicules in the stalk-like portion of these specimens shows that they belong to this species and not to *Ascetta primordialis*, Hkl., some varieties (especially *Nardorus primordialis*)* of which they resemble very closely. For figures and descriptions see Bowerbank †

* Hæckel, "Die Kalkschwæmme," vol. iii., pl. ii., fig. 5.

† Bowerbank, loc. cit. vol. ii., p. 22 ; vol. iii., pl. iv.

and Hæckel.* Two specimens, which in my former report I recorded as *Ascetta primordialis*, are also referable to this species.

Leucaltis impressa, n. sp. (Pl. XV., figs. 1—3).

I found three specimens of this new species at Puffin Island, April, 1889, in one of the large tidal pools on the north-east end of the island. The sponge consists of a solitary persona, which has an elongate and somewhat flattened shape. In two of the specimens the surface is longitudinally corrugated, but is even in the third specimen; it is, however, smooth in all three cases, and hard to the touch. The average height is 12 mm., the diameters in the two horizontal directions 6 mm. and 4 mm. The osculum is terminal, it bears no frill, and measures 0·5 mm. in diameter. The colour is white.

A transverse section shows a thick body-wall and a gastral cavity of about the same width as the body-wall. The diameter of the gastral cavity is therefore only about one-third of the diameter of the whole specimen. The flagellated chambers are spherical or ovoid and exceedingly numerous. They measure from 0·09 mm. to 0·18 mm. in diameter. The inhalent canals branch and anastomose between the flagellated chambers, and open finally into the gastral cavity. These openings are 0·05 to 0·1 mm. in diameter.

The skeleton of the body-wall and of the outer surface consists of triacts and tetracts. The former are by far the more numerous, and each of their rays measures about 0·1 mm. by 0·008 mm. There are also a few triacts with rays of 0·16 mm. in length. In all these triacts one of the rays is straight, the two others slightly curved. The tetracts which are found in the outer surface and in the body-wall generally have about the same dimensions as the triacts,

* Hæckel, loc. cit., vol. ii., p. 70 ; vol. iii., pl. xi , fig. 2.

but their fourth ray, which stands vertically upon the three others, is short and hook-like. It measures 0·03 mm. In addition to these spicules we find large gastral tetract spicules. They consist of three short rays (0·14 mm.) which lie in one plane, and of a fourth long ray (0·43 mm.), which stands at right angles to the former. The short rays are slightly curved, they lie in the inner surface of the body-wall and parallel to its circumference. The fourth ray projects freely into the gastral cavity. These tetract spicules are very numerous, so that their short rays form a kind of dense basket-work on the inner surface of the body-wall.

The spherical flagellated chambers of this species and its ramifying canals place it amongst the Leuconidæ, and its triact and tetract spicules bring it under the genus *Leucaltis*, Hæckel. Following now Hæckel's "Ubersicht der 6 Species des Genus *Leucaltis*,"* and taking no notice of the tetracts with the one hook-like ray, we arrive at *Leucaltis pumila*, Bowerbank. The respective steps in that "Ubersicht" are: 1. "Skelet nicht scharf getrennt in ein völlig verschiedenes Rinden-und Mark-Skelet." 2. "Hauptmasse des Skelets aus Dreistrahlern gebildet.' 3. "Vierstrahler entweder bloss in der dermalen oder bloss in der gastralen Fläche. Alle oder ein Theil der Dreistrahler und Vierstrahler nicht regulär." 4. "Vierstrahler bloss in der stacheligen gastralen und canalen Fläche." 5. "Basal Strahl der Vierstrahler länger als die lateralen.—*Leucaltis pumila*." Yet when we compare the specific characters of *Leucaltis pumila*, as given in the detailed descriptions of Hæckel and Bowerbank,† with our species, we find so many and such great differences between these two forms that I feel obliged to establish a new

* Hæckel, "Die Kalkschwæmme," Bd. ii., p. 143.

† Bowerbank, "British Spongiadæ," vol. ii., p. 41.

species. These differences are: 1. In *Leucaltis pumila* there are no tetracts with hook-like rays, such as are found in *Leucaltis impressa.* 2. The proportion in size of the gastral tetracts is different in the two species, the stalk being much longer in the new form. 3. The inner surface of the body-wall in *Leucaltis impressa* appears not to be provided with triacts in addition to tetracts as in *Leucaltis pumila.* 4. Bowerbank mentions the "very large size of the surface spicula" in *Leucaltis pumila*, of which there is no trace in our species.

I may mention that *Leucaltis pumila* has, according to Hæckel, a very wide geographical distribution. It has been found at Guernsey by Norman; at Magador (coast of Morocco) by Hæckel; at the Cape by Wilhelm Bleek; and in the Indian Ocean (Bass Strait) by Wendt.

Leucandra gossei, Bowerbank.

This form had previously been recorded from Port Erin and Holyhead. A few specimens of it have been collected again at Port Erin (April, 1889, and April, 1890), and also at Fleshwick Bay (April, 1890). It is one of the rarest calcareous sponges in our district.

Leucandra johnstoni, Carter.

A number of fine specimens of it were collected by me at Fleshwick Bay, Isle of Man, and a few also at Port Erin, in April, 1890. It had previously been found at Port Erin and Holyhead.

Leucandra nivea, Fleming.

In Mr. Higgin's report this species was recorded from the Isle of Man only. I have found it since, and in profusion, at Puffin Island, April, 1889; and a few specimens also at Hilbre Island, June, 1889. An unusually large and highly corrugated specimen of it, recalling *Leucandra johnstonia*, C., was collected by Mr. Charles Walker at Fleshwick Bay, April, 1890.

It generally forms small white patches on the rocks, and is easily recognizable.

Sycandra ciliata, Fleming.

Owing to an oversight *Sycandra ciliata* was not recorded in the two previous reports as having been found at Hilbre Island. It had been collected there in the summer of 1885 by the members of the Liverpool Marine Biological Committee,* and I have found a few small specimens of it in the same locality in March, 1890. Common in other parts of the district.

Explanation of the Plates.

ch. choanosome.
cy. cystenchymatous tissue.
d.m. dermal membrane.
e. ectosome.
e.c. exhalent canals.
f.c. flagellated chambers.
i.c. inhalent canals.
m. gastric cavity.
p.a. pore area.
p.c. "problematic cells."
pg. pigment cells.
pr. prionorrhabds.
s.c. subdermal cavities.
s.l. layer of scleroblasts (?).

Plate X.

Fig. 1. Vertical section through outer portion of *Halisarca rubra*, n. sp., semi-diagrammatic (× 250).

Fig. 2. Vertical section through inner portion of *Halisarca rubra*, n. sp. (× 250). It is doubtful whether the parts in figs. 1 and 2, named "i. c.," are inhalent or exhalent canals.

Fig. 3. *Axinella mammillata*, n. sp., natural size.

Fig. 4. Scleroblasts (?) of *Axinella mammillata* (× 800).

Fig. 5. Portion of a longitudinal section through one of the papillæ of *Axinella mammillata* (× 150).

Plate XI.

Fig. 1. *Chalina montagui*, Johnston, natural size.

*W. A. Herdman, in "Introduction" to "Fauna of Liverpool Bay," Vol. I. p. 8.

Fig. 2. Vertical section through the massive form of *Cliona celata*, Grant (× 3).

PLATE XII.

Fig. 1. *Cliona celata*, Grant, not quite one-half natural size.

PLATE XIII.

Fig. 1. A portion of the choanosome of *Seiriola compacta*, Hanitsch, showing chamber-system, strand of "problematic cells" (in longitudinal section), and cystenchymatous tissue (× 250).

Fig. 2. Transverse section through a strand of "problematic cells" of *Seiriola compacta*, with cystenchymatous tissue around it (× 250).

Fig. 3. Section through the choanosome of *Seiriola compacta*, showing the branching of the strands of "problematic cells" (× 50).

Fig. 4. Portion of fibrous layer of *Seiriola compacta*, situated between ectosome and choanosome (× 250).

PLATE XIV.

Fig. 1. Vertical section through the upper portion of the ectosome of *Stelletta collingsi*, Bowerbank. The encroaching *Sycandra ciliata* (in the upper left corner of the plate), shown diagrammatically, (× 200).

Fig. 2. Spined portion of a prionorrhabd (× 800).

Fig. 3. *a*, chiaster (× 800); *b*, *c*, and *d*, forms of oxyaster (× 400).

Fig. 4. *a*, protriæna; *b*, dichotriæna (× 60).

PLATE XV.

Fig. 1. Portion of transverse section through *Leucaltis impressa*, n. sp. (× 80).

Fig. 2. Two specimens of *Leucaltis impressa*, natural size.

Fig. 3. *a*, *b*, *c*, and *d*, triacts and tetracts of the body-wall (× 150); *f*, gastral tetract (× 150).

REPORT on the HIGHER CRUSTACEA of LIVERPOOL BAY taken in 1889.*

By Alfred O. Walker, F.L.S.,

With Plate XVI.

[Read May 9th, 1890.]

The operations of the L.M.B.C. during 1889 have on the whole been very successful as regards the higher Crustacea, and especially the Amphipoda. Many new species have been added to the fauna of Liverpool Bay and a few to that of the British Isles.

Adopting the same plan as in the previous two Reports, the localities where work has been carried on may be enumerated as follows:—

I. Puffin Island—chiefly shore hunting.

II. Isle of Man, visited at Easter, when the electric light was used at various depths. These are indicated in the Report by E.L.b. and E.L.s. for the bottom and surface respectively.

III. Colwyn Bay from the Little Orme (8 fath.) to Penmaenrhos. The greater part of the species collected here were obtained by using a small dredge with a frame of sheet brass 12in. long by 2½in. wide with a bag of "cheese-cloth" open at the tail end but closed by a wrapping of string. A small lead weight was attached to the dredge cord about 3ft. in front of the dredge. After dragging the dredge for a short time on sandy ground it would be brought up containing a considerable quantity of

* See former Reports in "Fauna of Liverpool Bay," Vol. I., 1886, pp. 221—226, and in Vol. II., pp. 171—181 and pp. 68—85.

sand. The bag was untied over a small bucket of sea water, into which the sand was dropped and, after being well stirred round with the sand, allowed to settle for a few seconds, when the water was poured through a muslin bag with a moveable ½in. brass sieve over its mouth to stop the larger pieces of weed, &c. Most of the Crustacea pass into the bag with the water, and after repeating the stirring and straining process the sand is thrown away. The dredge is put out again as soon as it has been emptied and is working while the washing and straining is going on. The muslin bag containing the living animals collected is then everted into a wide-mouthed glass jar (a French plum jar is the best) filled with sea water. This may be taken home and the contents emptied into dishes when most of the Crustacea will swim out of the weed and sand that still remains and be captured by a small muslin ring net; or the bag may be at once turned out into a bottle of spirit, or spirit, glycerine and water, to be examined at leisure. The number of creatures that are taken by this method in places that are absolutely barren to the dredge with a net bag, is astonishing. I have to thank Dr. Norman for showing me this excellent device. In shore-hunting it was found a good plan to wash Algæ in a bucket, pouring the water after several such washings through a muslin net which is then treated as above. This appears to be the best method of obtaining *Podocerus isopus* in March and April.

IV. The coast of Anglesey, from Puffin Island to Porthwen Bay (13 to 22 fathoms), "Spindrift" trip on June 8th. See Dr. Herdman's "Third Report on the Puffin Island Biological Station," p. 33.

V. The deep water (40 to 60 fathoms) between Holyhead and the Isle of Man, "Spindrift" trip on July 20. "Third Report on the Puffin Island Biological Station," p. 36.

VI. The shore at low tide in Moelfre Bay, Anglesey, where Mr. F. Archer made some collections in August.

The following species, not previously recorded in the several localities, were taken during 1889:—

I. Puffin Island.

* *Mysis ornata* (2)§, Sars. Off the Lighthouse; one male.

Janira maculosa, Leach. W. Spit; low-water.

Jæra nordmanni, Rathke. S. side of island; low-water.

* *Pleustes glaber* (12), Boeck. Shore; Feb., I. C. T.

† *Tritæta dolichonyx* (13), Nebeski. On Compound Ascidians; W. spit; low-water, with *Tritæta gibbosa*.

* *Microprotopus maculatus*, Norman. Turbot Hole, 15 fath.

* *Corophium bonellii*, M. Edwards. Ditto ditto.

II. Port Erin, Isle of Man, Easter, 1889, "Hyæna", E.L. = Electric Light; s. = surface; b. = bottom.

† *Siriella norvegica* (1), Sars. E.L. s. Several, chiefly males.

* *Gastrosaccus spinifer*, Goes. do. A few males and females.

* *Conilera cylindracea*, Montagu. One at sea (? on floating weed).

Sphæroma rugicauda (?) (8), Leach.
* *Cymadocea emarginata* (8), Leach. } Found together in a dead Balanus shell, 1888, (W. A. H.)

Tryphosa ciliata, Sars. E.L., 5 fathoms. One young.

* *Pontocrates haplocheles*, Grube. E.L. b. Three; also one in 1888, at E.L. in Ramsey Harbour.

Tritæta dolichonyx, Nebeski. E.L. b. Six males.

Halirages bispinosus, Bate. E.L. s. and b. Common.

Calliopius leviusculus, Kröyer. E.L. s. Several.

Calliopius norvegicus, Boeck. E.L., 5 fath. One female.

* *Leucothoe spinicarpa*, Abildgaard. Four; from branchial sac of *Ascidia venosa*, "Hyæna," May 20, 1888.

* Not previously recorded in Fauna of Liverpool Bay.

† ,, ,, ,, of Great Britain.

§ The numbers following the names refer to the succeeding notes, p. 244.

Amathilla sabini, Leach. E.L. s. Common.
Gammarus locusta, Linn. ditto ditto.

Fleshwick Bay, Isle of Man, same trip, shore.
Stenothoe monoculoides, Mont. One.
Calliopius norvegicus, Boeck. Several.

III. Colwyn Bay, 2½ fath. to 8 fath. (Little Orme).
Gastrosaccus spinifer, Goes.
* *Mysis neglecta* (3), Sars. Rhos Bay, low tide, June 15.
* *Mysis inermis*, Rathke. Shore; Penmaen Rhos, Aug. 11. One adult.
Mysis ornata, Sars. Shore to 8 fathoms. Several.
Cuma scorpioides (4), Montague. Little Orme, Sept. 18.
Iphinoe trispinosa, Goodsir. Colwyn Bay; 2½ fathoms, sand. Several females.
* *Lamprops fasciata* (5), Sars. Colwyn Bay and Little Orme. Several, males and females.
* *Diastylis spinosa* (6), Norman. Colwyn Bay.
* *D. rathkei*, Kr. Two immature males; Little Orme; Sept. 18.
Pseudocuma cercaria (7), van Beneden. Colwyn Bay. Abundant.
Dynamene rubra, Montague. Penmaenrhos shore.
Astacilla longicornis (9), Sowerby. Little Orme, and shore Colwyn Bay, Sept. 2.
† *Metopa rubro-vittata* (10), Sars. Little Orme. Several.
Stenothoe marina, Bate. ditto One.
Amphilochus manudens (11), Bate. ditto Several.
Iphimedia obesa, Rathke. Colwyn Bay. Scarce.
* *Danaia dubia*, Bate. Little Orme. A few.
Monoculodes longimanus, Bate and Westwood. Common in sand.
Megaluropus agilis, Norman. Rather common.
Pleustes glaber, Boeck. Little Orme. One.
† *Atylus falcatus* (14), Metzger. ditto, Colwyn Bay; a few.

Microprotopus maculatus, Norman. do., Rather common.

Aora gracilis, Bate. Little Orme and Colwyn Bay. Rather common.

Corophium bonellii, M. Edwards. Little Orme. One.

Dulichia porrecta, Bate. Little Orme and C. Bay. Several.

Podalirius typicus, Kröyer, ditto ditto ditto.

IV. "Spindrift" trip from Puffin Island to Porthwen Bay, Anglesey, June 8, 13 to 21 fathoms.

Portunus pusillus, Leach. Dulas Bay; three specimens.

Ebalia tuberosa, Pennant. ditto two ditto.

Ebalia tumefacta, Montague. ditto four ditto.

Anapagurus hyndmanni, Thompson. Two miles off Porthwen Bay. One small specimen.

* *Galathea nexa*, Embleton. Two specimens.

* *Crangon nanus*, Kröyer. Turbot Hole. Two females with ova.

Crangon allmanni, Kinahan. Three miles off Dulas Bay. One young.

Mysis ornata, Sars. Turbot Hole. One young.

Mysis inermis, Rathke (?). Dulas Bay. Young.

Cuma scorpioides, Montague. ditto. One female with ova.

Lamprops fasciata, Sars. Three miles off Dulas Bay. One female.

Atylus falcatus, Metzger. Off Red Wharf Bay. One female with ova.

* *Lilljeborgia pallida* (15), Bate. Porthwen Bay. One.

Photis longicaudatus, Bate. Dulas Bay; one young female.

* *Autonoe longipes*, Lilljeborg. One male.

Podoceropsis rimapalma, Bate. A few males and females.

* *Podocerus ocius*, Bate. Turbot Hole. Two females.

* *Unciola irrorata*, Say. Several specimens.

* *Unciola planipes*, Norman. Red Wharf and Dulas Bays. Several.

V. Second "Spindrift" trip, 16 miles N. of Holyhead

July 20, 40 to 60 fathoms.

Xantho rivulosa, Risso.

Galathea nexa, Embleton. Several.

Galathea dispersa, Bate. One.

* *Hippolyte spinus*, Sowerby. One specimen.

Pandalus brevirostris, Rathke. One female.

Pandalus annulicornis, Leach.

Janira maculosa, Leach. Two.

Euonyx chelatus, Norman. Abundant on *Echinus sphæra*.

Pleustes bicuspis, Kröyer. Two.

Tritæta gibbosa, Bate. One.

Ampelisca tenuicornis, Lilljeborg. Two.

Gammaropsis erythrophthalmus, Lilljeb. One.

Podocerus falcatus, Montague, var. *pulchellus*. One.

Erichthonius (Cerapus) abditus, Templeton. A few, males and females.

"Hyæna" trip, May 21, 1888, 20 miles S.E. of Isle of Man, on sponge, 30 fathoms.

* *Colomastix pusilla*, Grube. Two (= *Cratippus tenuipes*, Bate and Westwood = *Exunguia stilipes*, Norman, in Ann. and Mag. N.H., 4th ser., vol. iii., p. 59.).

VI. Moelfre Bay, Anglesey ; low tide, Aug., F. Archer.

Dynamene rubra, Montague.

Dynamene montagui, Leach.

Calliopius norvegicus, Boeck. A few females.

Dexamine spinosa, Mont.

Amphithoe podoceroides, Rathke. Abundant.

* *Sunamphithoe gammaroides* (16), Bate. Several, males and females.

Caprella acanthifera Leach. Many, with well-developed spines.

Notes on the above Species.

1. *Siriella norvegica*, Sars.

To this species I refer several males and one or two females taken with the electric light. The general characters and the peculiar tridentate spinule at the extremity of the telson agree with Sars' description. The spines, however, on the inner edge of the inner uropods agree rather with those of *S. crassipes*, Sars, (from which species this differs in its longer limbs) in having no small spines between the larger, all being nearly equal in size and set closely together, except towards the extremity. A female examined had three setæ on the inner margin of the last joint of the peduncle of the upper antennæ, and two setæ on the distal extremity of that joint, which agrees with Sars' figure. Length about 15 mm. from tip of antennal scale to tip of telson.

2. *Mysis ornata*, Sars.

In Report I., p. 221, I have erroneously recorded *M. spiritus* (Norman) for this species, which is not uncommon in Liverpool Bay. It may be known from *M. spiritus* by its short, thick eye-stalks, and by having only five joints in the tarsi of the anterior legs instead of seven to nine.

3. *Mysis neglecta*, Sars.

This species is sometimes abundant in tidal pools in June and July. The colour varies from the faintest tint of green (almost colourless) to dark olive-green. The greater number were grass-green. All had the peduncle and inner branch of the upper antennæ, the eyes, and tips of both branches of the uropods, golden-yellow. The fringes (setæ) of the antennal scales and uropods were red-purple. A large living specimen, which was of the usual pale grass-green when taken out of the white dish in which it was swimming, placed in a watch-glass on a black glass plate, became in about an hour dark olive-green, while a smaller and almost colourless specimen lost what little colour it had. Some specimens were much infested on the head and thorax by an *Epistylis*. This species differs from *M. flexuosa* (Müller) in having only five joints in the anterior tarsi instead of six, and in the antennal scale being barely twice as long, instead of more than twice as long, as the peduncle of the upper antennæ.

4. *Cuma scorpioides*, Mont.

I have referred the specimens taken to this species as the oldest. Nevertheless if Sars is correct in saying that this species is distinguished from *C. edwardsi*, Goodsir, (among other characters) by the inner branch of the uropods consisting of one single joint instead of two joints as in *C. edwardsi*,* then our specimens should be referred to the last-named species. Sars also states that *C. edwardsi* may be distinguished from *C. scorpioides* "by its shorter length and by its dark brown-violet colour."† But all my specimens, except one, are of a sandy colour, and that one, which is almost black, was taken at the same time and place as two or three sandy-coloured individuals, from which it does not differ in structure. Hoek appears to be doubtful whether these two forms are specifically distinct.‡ Goodsir's description§ of *C. edwardsi* and *C. audouinii* is so full of errors that it is impossible to make much of it. The figure of *C. audouinii* shows indications of pleopoda, which are not mentioned in the description, and I am inclined to think that one of the above species is the female and the other the immature male of *C. scorpioides*. The "thumb-like process" of the "first pair of legs" (the third maxillipedes) is merely the external extremity of the first joint, and is, of course, not jointed at all. No such jointed process at the extremity of this, as described and figured by Goodsir, exists in the Cumacea,

* Middlehavet's Cumaceer, p. 21.

† Oversigt af Norge's Crustaceer, p. 55.

‡ Nederlandsche Dierkundige Vereen., 1889, Deel 2, p. 2.

§ Edinburgh New Phil. Journal, 1843 ; vol. 34, pp. 123—6. pl. ii. & iv.

yet he makes the difference between the above two species largely to depend on the number of joints in it. Until it is proved more clearly than it seems to be at present, that there is more than one species having the characteristic raised lateral line on the carapace and free thoracic segments parallel with the dorsal outline, I must incline to the opinion that both the above species should be referred to *C. scorpioides* (Montague). It is to be noted that the two species of Goodsir are evidently both straw-coloured, which does not agree with Sars' definition.

5. *Lamprops fasciata*, Sars.* (Pl. XVI., figs. 1-3.)

Several specimens were taken, mostly females. The largest female measured 7½ mm. from point of rostrum to tip of telson. Sars, who describes the female only, gives 4½ mm. as the length. In the male the carapace equals in length the first three thoracic segments. The lower antennæ reach to the end of the second free thoracic segment; the peduncle is thick and densely furred on the upper side. This species resembles *Pseudocuma cercaria* in having three oblique striæ or folds on the sides of the carapace, but it may be at once distinguished by its well developed telson and larger size. The peduncle of the uropoda has eight spines on the inner margin, of which the six distal are compound, i.e., are themselves spinous. It has been taken by Mr. D. Robertson in the Firth of Clyde, and at Tarbert, Loch Fyne.

6. *Diastylis spinosa*, Norman (Brit. Ass. Report, 1868, p. 271.).

Diastylis bimarginatus, Bate (A. & M.N.H., ser. 5, vol. i., p. 409, and cut).
,, ,, Sim (,, ser. 5, vol. ii., p. 453, pl. xviii).
D. bradyi, Norman (Ann. and Mag., N.H., ser. 5, vol. iii., p. 59).

There can, I think, be no doubt that *D. bradyi* is the female of *D. spinosa*. Although adult males are rare, yet,

* Om den aberrante Krebsdyrgruppe Cumacea, &c., p. 191; and Norman, Ann. and Mag. N. H., 1887, p. 100.

as a few of these and *no other adult males* and a large number of *D. bradyi*—all females or immature males, and *no other species of female*—have been taken together in Colwyn Bay on more than one occasion, it is impossible to suppose that they can be other than the same species. Prof. G. O. Sars, to whom I sent specimens, has been good enough to inform me that he was misled by a damaged specimen of *D. spinosa* in referring to it as its female *D. echinata*, Bate.* He adds, "I now regard your identification of *D. spinosa* as the adult male of *D. bradyi* to be most likely correct." The immature male attains its full growth before acquiring the spinous pleon of the adult, this being, until the last moult, even less spinous than in the female.

7. *Pseudocuma cercaria*, van Beneden.

Very abundant in sand; Colwyn Bay.

8. *Cymadocea emarginata*, Leach.

Sphæroma rugicauda, Leach.

These were found together in a dead *Balanus* shell, a circumstance which lends support to Hesse's opinion that *Sphæroma* is the female of *Cymadocea*.†

9. *Astacilla longicornis*, Sow.

Arcturus longicornis, Bate and Westwood.

Two specimens were taken, one at low-water with the young (which, being cream-coloured, contrasted strongly with the dark brown parent) attached to the long outer antennæ, as described by Bate and Westwood, by their hind legs. They sometimes left their perch and returned to it after swimming about. This species has been recorded from the mouth of the Dee by Mr. Byerley.

10. *Metopa rubro-vittata*, G. O. Sars.

This appears to be rather a common species in Colwyn Bay. Two or three specimens were beautifully and

* "Challenger" expedition, Zoology, Report on Cumacea, p. 50.

† Ann. des Sciences Nat., 5th ser., vol. xvii., p. 1, &c.

regularly spotted or speckled with bright crimson.

11. *Amphilochus manudens*, Bate.

As illustrating how little dependence can be placed on colour in the determination of species, I may mention that among several specimens taken at the same time all, except one, *which was bright scarlet*, were mottled with brown, and in one or two instances, almost entirely black.

12. *Pleustes glaber*, Boeck.

Pleustes (Paramphithoe) assimilis, G. O. Sars.

It appears to be somewhat doubtful whether these are specifically distinct. The principal distinction is in the hinder angle of the third pleon segment, and this is variable in the few specimens I have, which seem rather referable to the var. *assimilis*. Mr. D. Robertson also suggests the identity of the two species.* I prefer to retain the older genus *Pleustes*, as expanded by Boeck, in place of *Paramphithoe*, for which there seems to be no necessity.†

13. *Tritæta dolichonyx*, Nebeski. (Pl. XVI., figs. 4 and 6.)

I have little doubt that this is the adult male of *T. gibbosa* (Bate). Only the males appear to have the characteristic excavation in the anterior edge of the hand of the second gnathopods, and both Mr. D. Robertson ‡ and myself (Puffin Island, on Compound Ascidians) have taken them associated with *T. gibbosa*. It has been taken in the Adriatic and the Canary Islands. §

14. *Atylus falcatus*, Metzger.||

A. uncinatus, G. O. Sars (Oversigt af Norges Crust., p. 101, pl. v., 1882).

A. falcatus, Hoek (Tijdschrift der Nederland. Dierk. Vereen, 1889, Deel ii., p. 26, pl. viii).

* A Contribution towards a Catalogue of the Amphipoda and Isopoda of the Firth of Clyde. Trans. of the Glasgow Nat. Hist. Society, 1888, p. 94.

† "Challenger" Report on Amphipoda. Stebbing, pp. 424—870.

‡ Stebbing l.c., p. 520.

§ Walker, "Proc. Liverpool Biol. Society," Vol. II., p. 130 (1888).

|| Die wirbellosen Meeresthiere der ostfriesischen Küste. Hannover, 1871.

This species has occurred in two localities in the district. The single specimen from Red Wharf Bay (an ovigerous female) agreed with Sars' figure in having no dorsal teeth on the first three pleon segments as shown by Hoek. Those from Colwyn Bay, on the other hand, agreed with Hoek's figure in this respect. Both differed from Hoek's figure and agreed with Metzger's description and Sars' figure in having the hinder angle of the first three pleon segments produced backwards as a small tooth. The Red Wharf Bay specimen measured 6 mm.; an ovigerous female from Colwyn Bay 5 mm. None of my specimens have the remarkable first peræopod hairy, as shown in Hoek's figure. Mr. Stebbing, on the faith of Sars' description, has suggested that this species ought probably to be referred to the genus *Tritæta*,* but the presence of a mandibular palp seems to preclude this. Its general aspect also is much more that of an *Atylus* than a *Tritæta*.

15. *Lilljeborgia pallida*, Bate.

According to Bate and Westwood the third uropods "have the branches much shorter than the peduncle," while Boeck says they are "paulo longiores." My specimen agrees with Boeck.

16. *Sunamphithoe gammaroides*, Bate.

Amphithoe gammaroides, Bate and Westwood (Brit. Sess. Crust., p. 427).
Sunamphithoe gammaroides, Stebbing (Ann. and Mag. N.H., 4th ser., vol. xiv., p. 114, pl. 11 and 12).

This would appear to be a rare species. It is not in Dr. Norman's catalogue.

17. *Podocerus isopus*, Walker. (Pl. XVI. fig. 7.)

I have this year for the first time met with the adult male of this species. The second gnathopod is much larger in proportion to the first than in the immature male and female. The palm, however, is distinctly convex, and

* "Challenger" Report on Amphipoda, p. 941.

the hand cannot be described either as "*curvata*" (Boeck) or "*arcuata*" (Kröyer), the terms used by these two authors in their descriptions of *Podocerus anguipes* (Kröyer), which, in other respects (except size), this species much resembles. It occurred abundantly in tidal pools at dead low water in April.

Explanation of Plate XVI.

Figs. 1-3. *Lamprops fasciata*, Sars, adult male.
Fig. 1. Lower antenna.
2. Telson and right uropod.
3. Inner edge of peduncle of uropod.

Figs. 4-6. *Tritæta gibbosa*, Bate (= *Tritæta dolichonyx*, Nebeski), adult male.
Fig. 4. Peduncles of upper and lower antennæ.
5. First gnathopod.
6. Second do.

Fig. 7. *Podocerus isopus*, Walker, adult male ; first and second gnathopods.

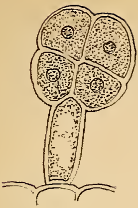


Fig. 4.

Fig. 6.

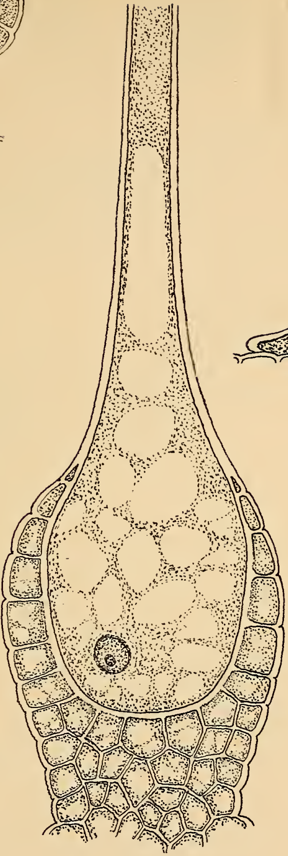


Fig. 5.

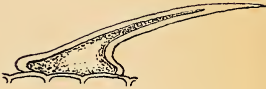


Fig. 3.

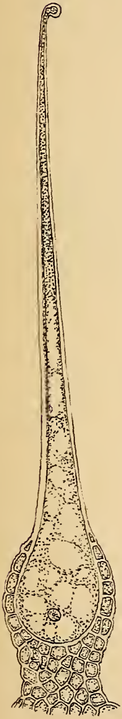


Fig. 1.

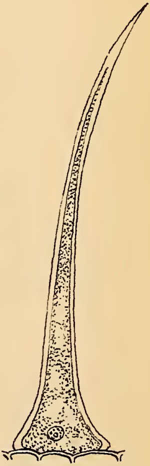
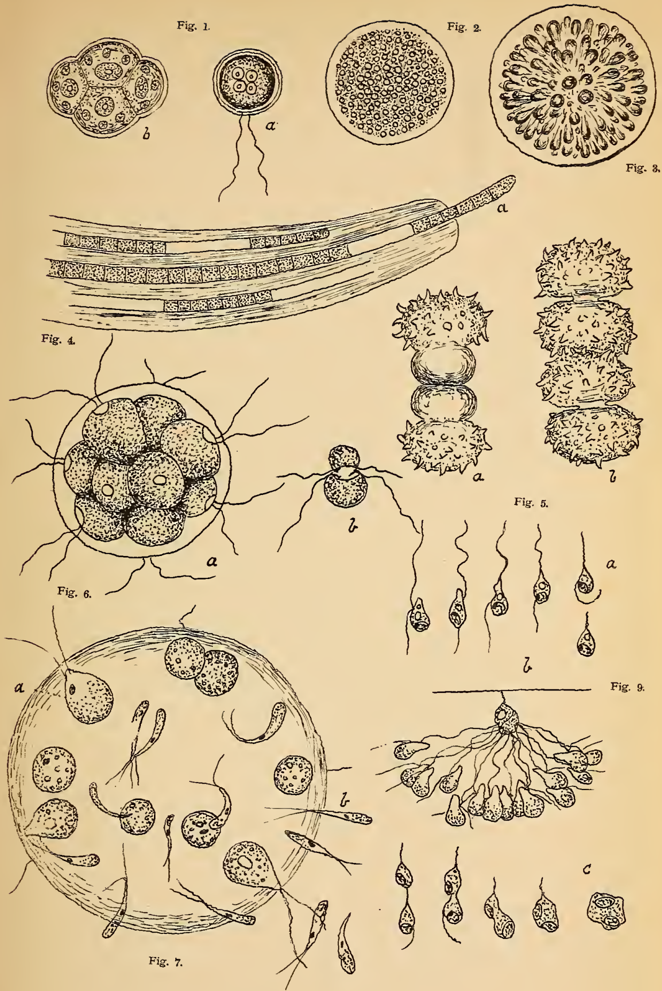


Fig. 2.

R. J. H. G., del.

URTICA DIOICA.



REPRODUCTION IN ALGÆ.

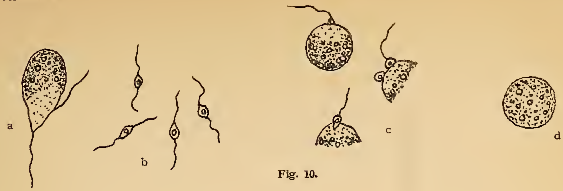


Fig. 10.

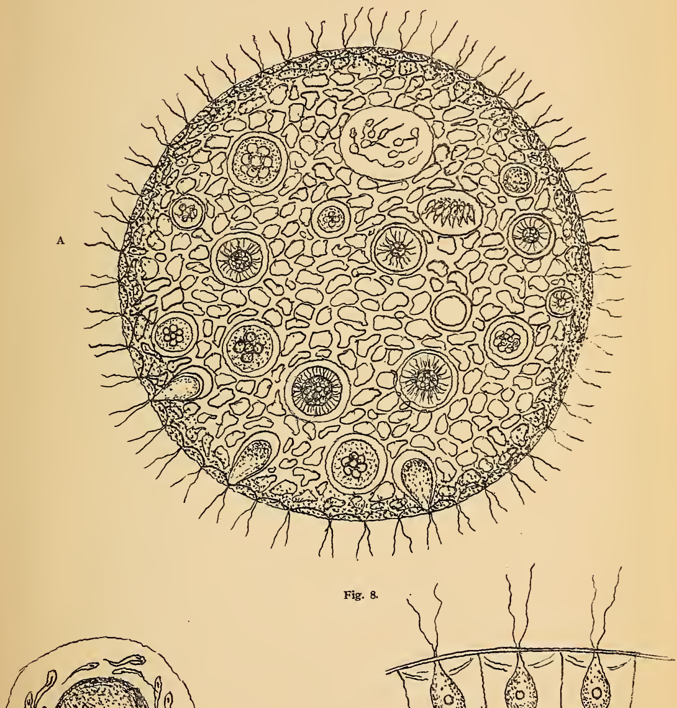


Fig. 8.

REPRODUCTION IN ALGÆ.

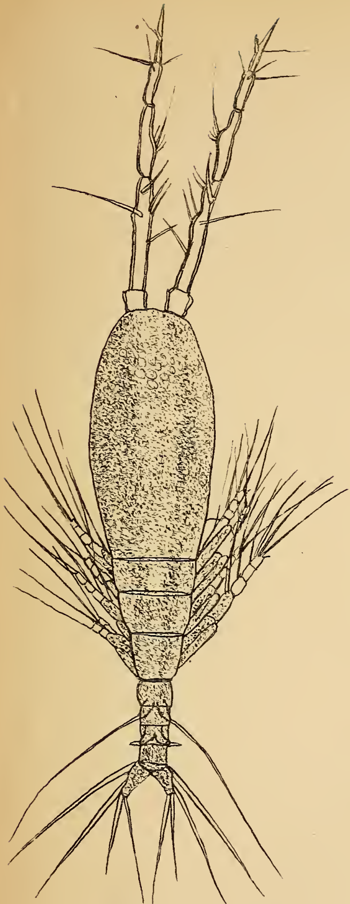


Fig. I.

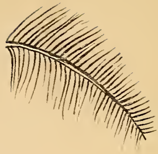


Fig. 3.

Fig. 4.

Fig. 5.

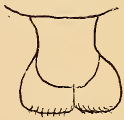


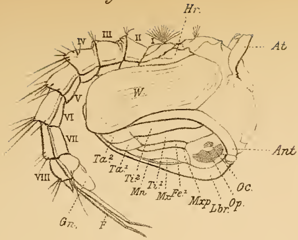
Fig. 6.

Fig. 2.

I. C. Thompson, del.

MONSTRILLA LONGICORNIS, N. SP. ♂ FIGS. 1, 2 & 4.
MONSTRILLA ANGLICA (LUBBOCK), ♂ FIGS. 3, 5. & 6

Fig. 1.



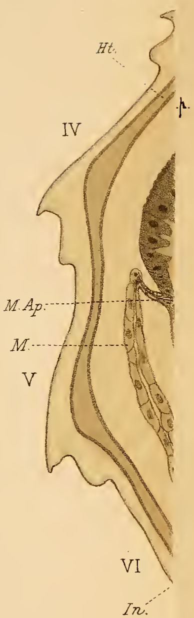


Fig. 2.

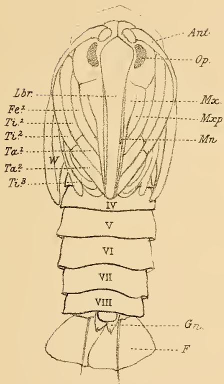


Fig. 5.

C Herbert Hurst del.

Fig. 1.

Fig. 2.

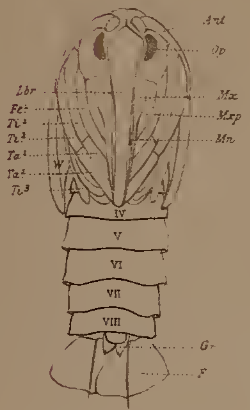


Fig. 3.

Fig. 7.

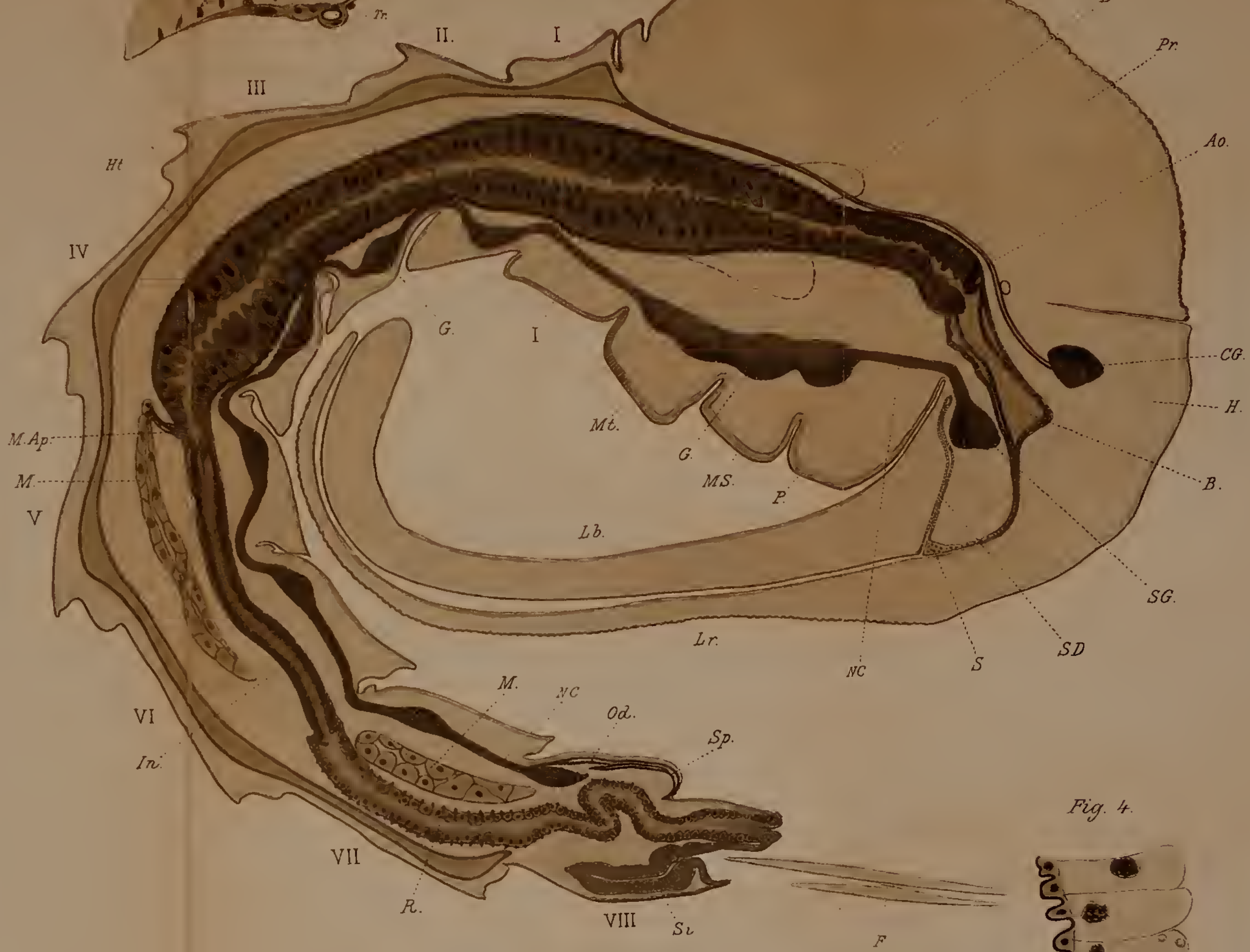


Fig. 4.

Fig. 5.

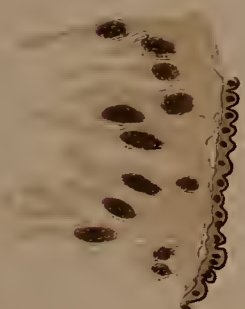
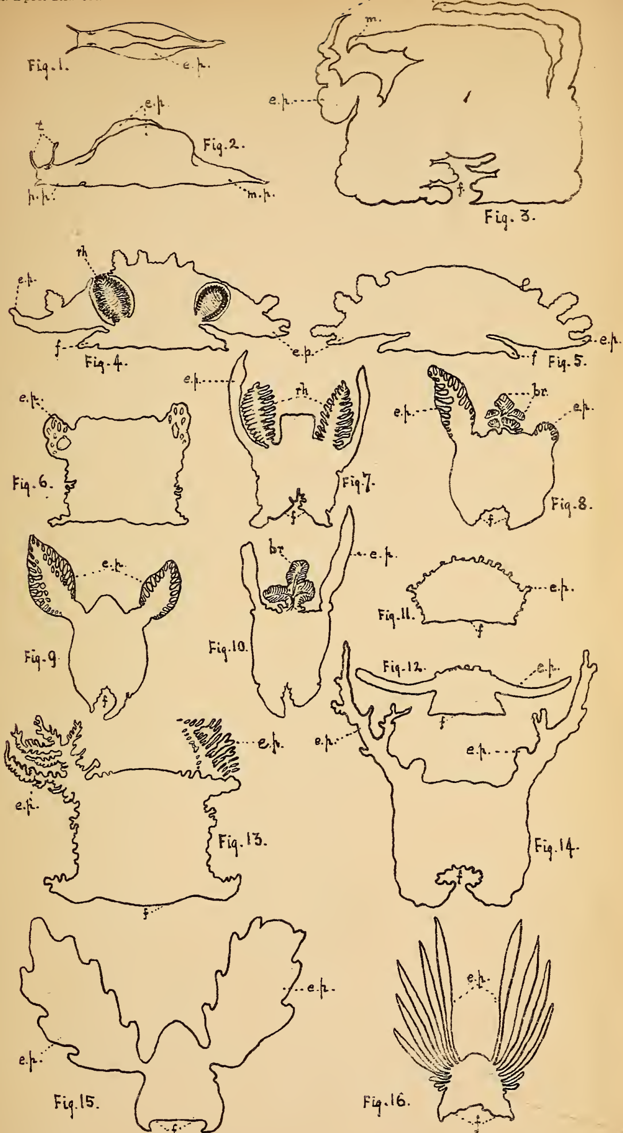


Fig. 6.

H... arst del.

F. Huth, Lith. Edin.

CULEX.



W.A.H. del.

EPIPODIAL PROCESSES.

Fig. 1.

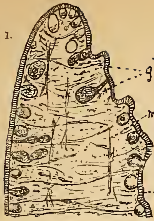


Fig. 2.

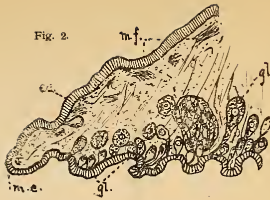


Fig. 3.

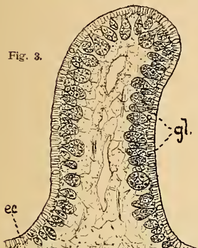


Fig. 4.

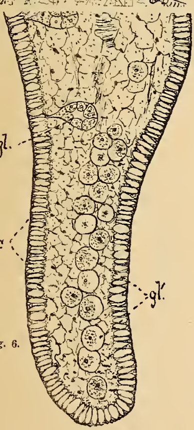


Fig. 6.

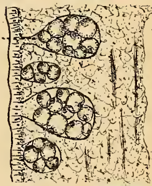


Fig. 9.

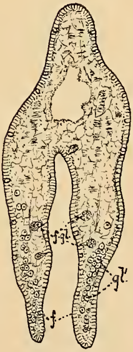


Fig. 5.

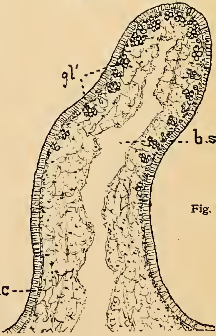
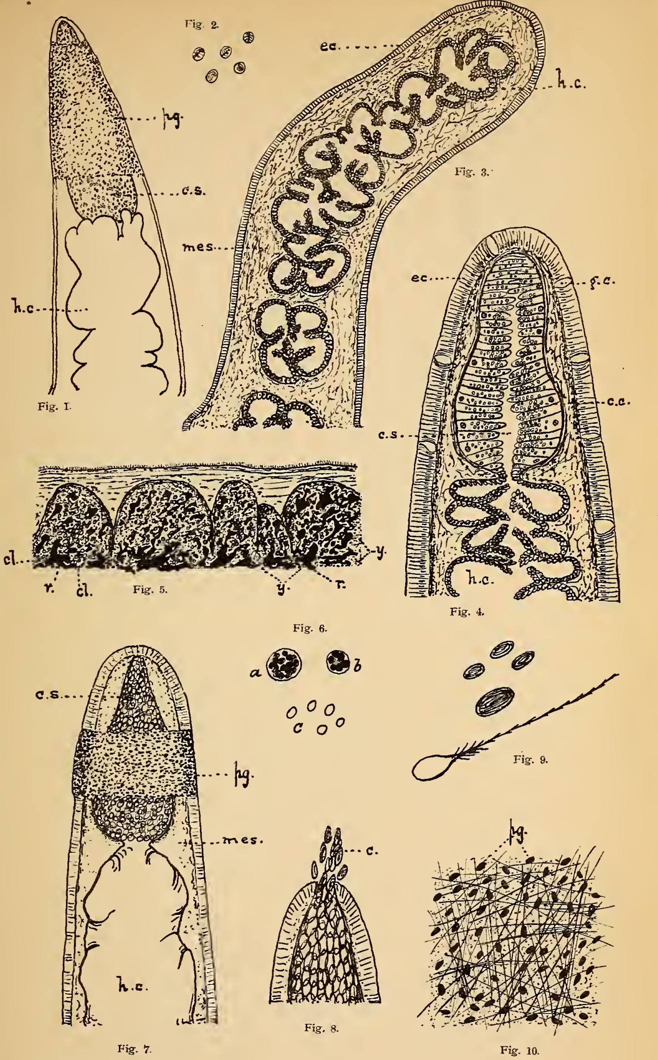


Fig. 8.

Fig. 7.

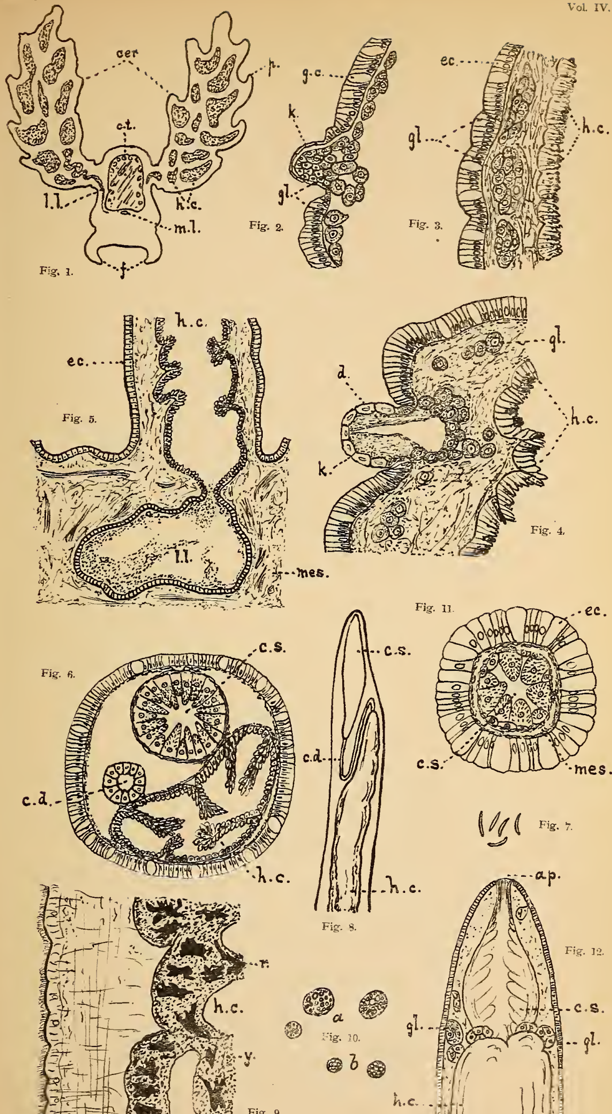
J. A. C., del.

Figs. 1 & 2, APLYSIA PUNCTATA.
Figs. 3 & 4, POLYCERA QUADRILINEATA. Figs. 5–9, ANCULA CRISTATA.



W. A. H., del.

FIGS. 1–6, CORYPHELLA RUFIBRANCHIALIS.
FIGS. 7–10, CORYPHELLA LANDSBURGI.



W. A. H., del.

FIGS. 1–4, DOTO CORONATA.
FIGS. 5–7, FACELINA CORONATA. FIGS. 8–10, FACELINA DRUMMONDI.
FIG. 11, GALVINA PICTA. FIG. 12, CRATENA VIRIDIS.

Fig. 1.

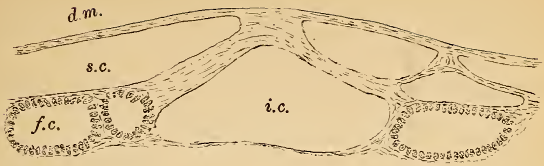


Fig. 2.

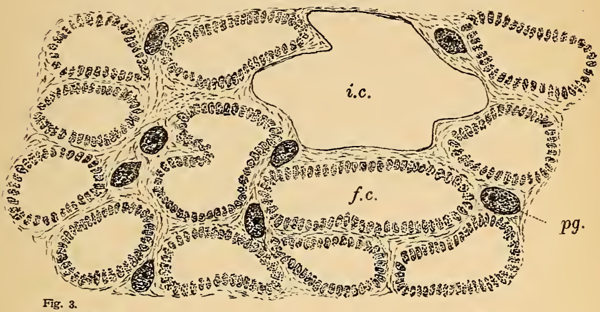
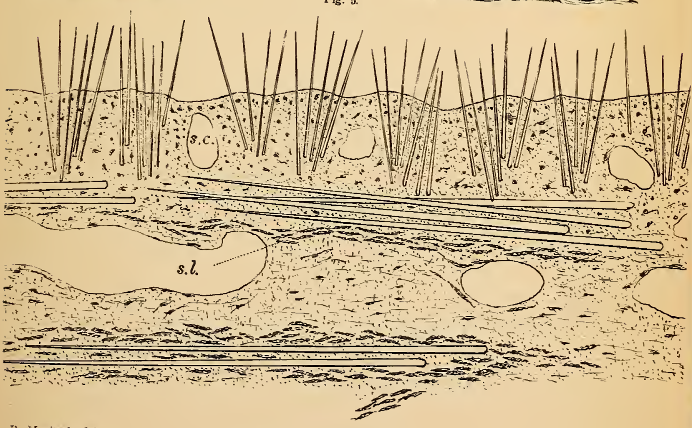


Fig. 3.

Fig. 4.

Fig. 5.



R. Hanitsch, del.

HALISARCA RUBRA, N. SP.
AXINELLA MAMMILLATA, N. SP.

Fig. 1.

Fig. 2.

R. Hanitsch, del.

CHALINA MONTAGUI, Johnston.
CLIONA CELATA, Grant.

R. Hanitsch, del.

CLIONA CELATA, GRANT.

Fig. 1.

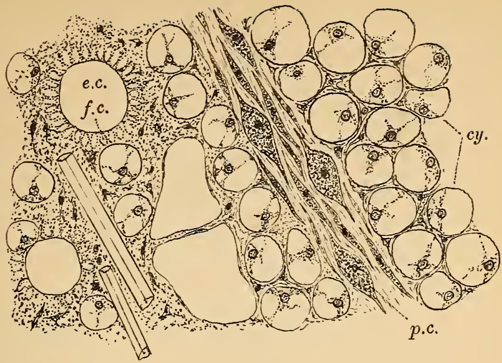
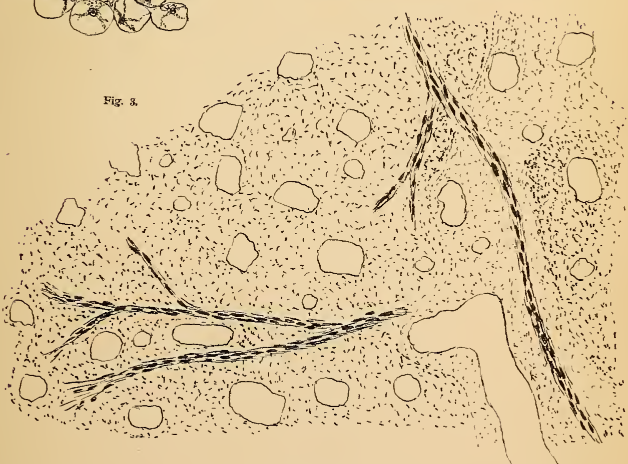


Fig. 2.

Fig. 4.

Fig. 3.



R. Hanitsch, del.

SEIRIOLA COMPACTA, HANITSCH.

Fig. 1.

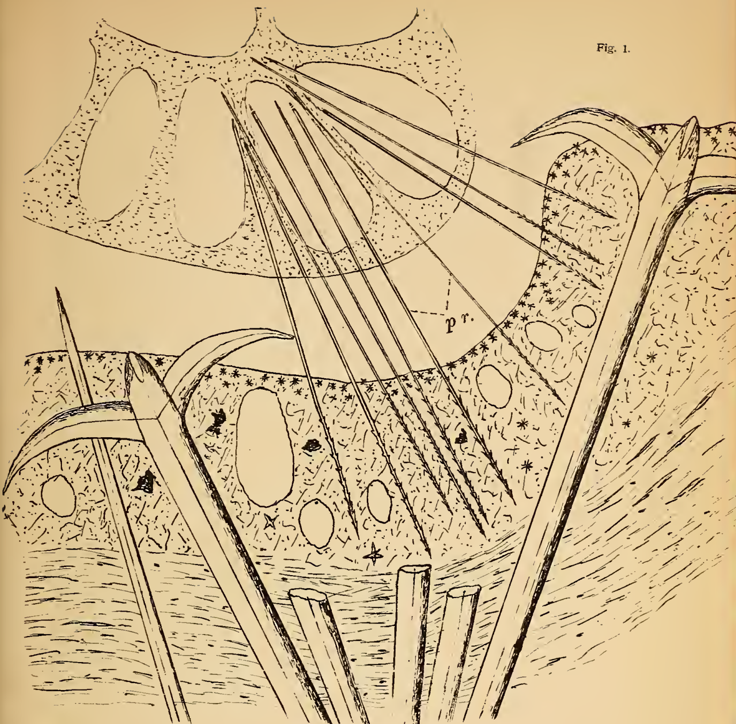


Fig. 2.

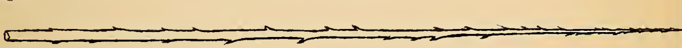
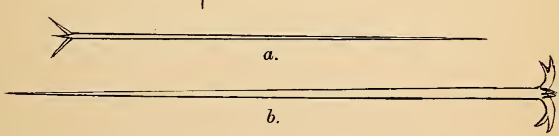


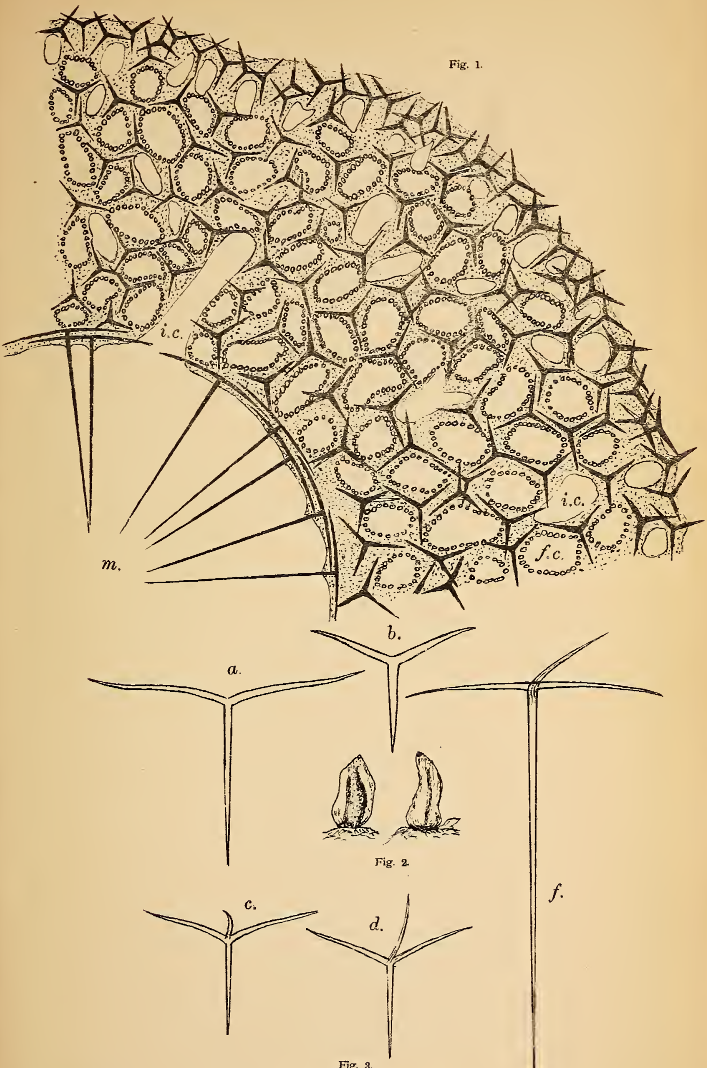
Fig. 3.

Fig. 4.



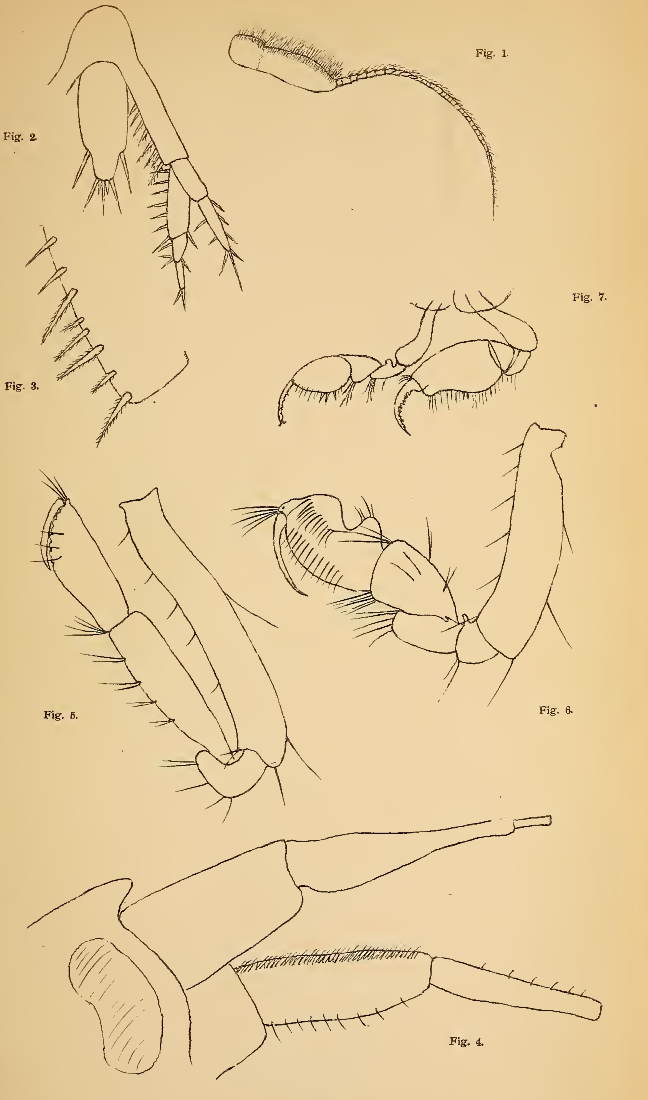
R. Hanitsch, del.

STELLETTA COLLINGSI, Bowerbank.



R. Hanitsch. del

LEUCALTIS IMPRESSA. N. SP.



FIGS. 1–3. LAMPROPS FASCIATA, SARS.
FIGS. 4–6. TRITÆTA GIBBOSA, BATE.
FIG. 7. PODOCERUS ISOPUS, WALKER.