Presented to
Dr H. I. Bowditch.
by his pupils in Auscultation
March - 1847.

ELEMENTS

OF THE

GENERAL AND MINUTE ANATOMY

OF

MAN AND THE MAMMALIA,

CHIEFLY AFTER ORIGINAL RESEARCHES.

BY

FR. GERBER,

PROSECTOR IN THE UNIVERSITY OF BERN.

TO WHICH ARE ADDED,

NOTES AND AN APPENDIX,

COMPRISING RESEARCHES ON THE ANATOMY OF THE BLOOD, CHYLE, LYMPH, THYMOUS FLUID, TUBERCLE, &c. &c.

BY

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TEXT AND APPENDIX.

LONDON:

HIPPOLYTE BAILLIERE, 219 REGENT STREET,

FOREIGN BOOKSELLER TO THE ROYAL SOCIETY, AND TO
THE ROYAL COLLEGE OF SURGEONS.

PARIS: J. B. BAILLIERE, RUE DE L'ECOLE DE MEDECINE.

LEIPSIG: T. O. WEIGEL.

M.DCCC.XLII.

LONDON:
PRINTED BY MOYES AND BARCLAY, CASTLE STREET,
LEICESTER SQUARE.

PREFACE.

General Anatomy, in connexion with that portion of physiological science which treats of the evolution of animals, has not only made signal progress in recent times, but in the interesting shape in which it now presents itself, has acquired new claims to our attention: more than this, it is found daily to gain in importance in its relations to natural science at large, and to scientific medicine in particular.

General Anatomy, indeed, is now seen to form the indispensable basis not only of descriptive anatomy, but of physiology and the science of evolution, and farther of morbid anatomy, and therefore of pathology. The changes that take place in the constitution of our organs, and that give form and character to a large proportion of the more formidable diseases to which we are obnoxious, occur in the elementary and constituent atoms of these organs; we can no longer sit down contented with such general affirmations of morbid states as satisfied our immediate predecessors,—*indurated, softened, enlarged, altered in appearance*, &c. &c. are expressions that cannot now be received; we would be informed of the changes that have taken place in the intimate structure of parts, and that have led to the induration, the softening, the enlargement, the alteration in appearance, &c.

The microscope, now recognised as indispensable in general and pathological anatomy, ought also to take its place among the implements most needful to the practical physician. It seems impossible, indeed, to over-estimate the extent to which the science and art of medicine would be advantaged were every well-informed and zealous practitioner carefully to examine each morbid product he encountered, and to communicate the results of his inquiries along with a compendious history of the case.

FR. GERBER.

Bern, 1840.

TO THE READER.

To Dr. Craigie belongs the merit of having written the first distinct and comprehensive English work on General Anatomy; Mr. Grainger's Treatise on the same subject appeared almost immediately afterwards, and the translation of Beclard's book, by Dr. Knox, soon followed.

All these works are valuable, and each has undoubtedly been of essential service in advancing the knowledge of Minute Anatomy in this country. But the progress of this branch of science has of late years been so rapid that, to give a tolerably accurate account of its present state, an entirely new publication has become necessary. The work of Gerber has been commended by Rudolph Wagner, "as the latest and best" on the subject of which it treats. That all we should like to see in such a treatise is accomplished, it would, I conceive, be vain to assert; but the work appears to me to be generally highly interesting, and I believe that it cannot fail to prove serviceable to English anatomists.

Improvement in science, with a few brilliant exceptions, is gradual; it results from the united toil of many observers; and if every careful and laborious effort be the means by which a step is gained, the present publication, like its predecessors, will certainly be useful.

The sheets of the English version of Mr. Gerber's work were submitted to me with the request that I would add some notes to the text. Hence the Appendix and the Notes marked "G. G.," which comprehend all that I have done on the occasion. The engravings illustrative of my observations are after drawings by Mr. Siddall, a zealous micrographer and the worthy veterinary surgeon of the Blues. I am also indebted to Dr. Boyd, the excellent resident physician of the St. Marylebone Infirmary, for his friendly assistance on various occasions.

GEORGE GULLIVER.

Windsor, November 1841.

CONTENTS.

GENERAL ANATOMY.

APPENDIX

BY

G. GULLIVER, F.R.S.

GENERAL ANATOMY.

INTRODUCTION.

ANATOMY is that branch of natural science which treats of the structure of organic bodies,— which investigates the connexions, forms, external and internal relations, and intimate constitution of all that is organised. Anatomy is, therefore, a generic term, including the consideration of the structure of man — HUMAN ANATOMY, OR ANTHROPOTOMY; of animals — COMPARATIVE ANATOMY, OR ZOOTOMY; and of plants — VEGETABLE ANATOMY, OR PHYTOTOMY. Anatomy is further necessarily distinguished, according as the healthy and natural structure is its object, NORMAL ANATOMY; or, as the diseased or abnormal structure engages attention, ABNORMAL ANATOMY. Abnormal anatomy is itself subdivided according as changes wrought by disease in the organs, originally of healthy constitution, are the object of contemplation, when it is entitled MORBID OR PATHOLOGICAL ANATOMY; or, as original and congenital deficiencies, superfluities, or imperfections are the subjects of study, when it is entitled the ANATOMY OF ANOMALY, or ANOMALOUS ANATOMY, PHILOSOPHICAL or TRANSCENDENTAL ANATOMY. When anatomy is cultivated merely as a science, and in books, it is spoken of as THEORETICAL ANATOMY; when researches are undertaken in the bodies of men, animals, &c. it is known as PRACTICAL ANATOMY, or the art of DISSECTION. The art of dissection is systematically pursued when the various, especially similar, parts of the *subject* are exposed in their sequence or connexions. When the several parts, again, especially of dissimilar nature, which enter into the constitution of each particular district of the body are exhibited in their several situations, and in their mutual mechanical relations, the study acquires the name of SURGICAL or REGIONAL ANATOMY. Finally, anatomy is divided into GENERAL and SPECIAL. The business of the GENERAL ANATOMY is to take cognisance of the most simple and minute, or elementary parts of organic bodies, and of the union of these in the composition of particular *organs*, such as the brain, the lungs, the liver, &c., and of certain *systems* into which they are found susceptible of arrangement, such as the fibrous, the muscular, the glandular, the nervous, &c. General Anatomy, further, under the name of Histology, studies the texture and mode of formation of the different compound organs, and indicates the reasons for the diversities they present. SPECIAL or DESCRIPTIVE ANATOMY, again, considers the forms, situations, relations, connexions, and modes of distribution of the several organs or systems which make up the body.

Anatomy, then, has the structure of organic beings for its object. But we do not limit ourselves to the study of the structure alone; we have ever an eye to something beyond this — to the uses or functions, namely, of the organs we discover. A new science is therefore engrafted upon anatomy, — a science which treats of the functions of organised beings, and this is entitled PHYSIOLOGY. Like anatomy, physiology is subdivided variously, and is appropriately designated according to the direction in which it is studied. We do not, however, speak of a morbid physiology as we do of a morbid anatomy, when we consider the functions of an organism in a state of disease. PATHOLOGY is the term which is here employed; so that pathology is to be understood as having the same relation to physiology which morbid anatomy has to normal anatomy. Anatomy and physiology, however, ought never to be viewed as sciences altogether disjoined and different; they are, indeed, so closely linked together, that they are all but one and the same: in anatomy, we study the organs *in repose*, in physiology, we study them *in action*.

It is now universally allowed that an adequate knowledge of the structure and functions of the human body is the only foundation of all medical science. Without this essential preliminary, it is just as impossible to distinguish disease, and to treat it rationally, as it is for a tree without roots to put forth blossoms and to bring fruit to maturity. Nor are the researches of the anatomist and physiologist confined in the present day to the structure and functions of the body of man alone. It is customary now to embrace all that has life,—to contemplate organisation in the linked chain which it forms, and to connect structures and functions of the first simplicity with structures and functions of the last complexity. It is, in fact, only since comparative anatomy and general physiology began to be seen as integral parts of a liberal professional education, that scientific, and then practical, medicine and surgery have made any thing like vigorous or assured strides in advance. If we be made but a little lower than the angels, we are also very certainly made but a little higher than the more perfect among the animals; and in studying the structure and functions of these especially, we find the most important aids to a right understanding of the mechanism by which we ourselves "live, and move, and have our being," and thence, under the guidance of reason and experience, of the means by which we may hope to ward off or to remedy the ills in the shape of infirmity and disease to which we are made obnoxious.

OF THE DISSECTION AND ELEMENTARY CONSTITUENTS OF THE ANIMAL BODY.

§ 1. The object of the ANATOMIST is to exhibit, in systematic arrangement, the organic constituents of the body, by investigating and separating the various organs of which it consists, indicating their similarities and their differences, discovering their mutual connexions, unravelling the tissues, laying the hidden open, and distinguishing the ultimate forms of organic matter with the aid of the magnifier and the microscope. The object of the CHEMIST, again, is to separate mingled elements without paying any regard to their form, texture, or arrangement.

§ 2. The organic constituents of the animal body are, like chemical elements generally, divisible into *proximate* or compound, and *remote* or simple : for example, the blood corpuscules form a proximate or compound organic element of the blood, the outer coverings and the nuclei of these bodies a remote or simple organic element of the same fluid; hydrogen and oxygen are simple, water and fibrine compound, chemical elements of the blood.

GENERAL ANIMAL CHEMISTRY.

REVIEW OF THE CHEMICAL CONSTITUENTS OF THE ANIMAL BODY.

§ 3. In inorganic bodies the chemical elements are always associated in twos, or they form binary combinations : for example, oxygen and iron, in certain proportions, form oxide of iron ; oxygen and sulphur, in certain proportions, form sulphuric acid ;

protoxide of iron and sulphuric acid form sulphate of the protoxide of iron,

Oxygen, Iron	Protoxide of Iron	Sulphate of the Protoxide of Iron.
Oxygen, Sulphur	Sulphuric Acid	

This binary combination prevails universally throughout the entire domain of inorganic nature, and is essential to quiescence or chemical equipoise: any other combination of chemical elements is incompatible with chemical quiescence, and is by so much the more vigorously opposed by surrounding media and influences, — air, water, caloric, electricity, light, &c., in order to reduce them to binary combinations, the more the kind of combination attempted is remote from the binary; the vital force alone, assisted by ceaseless changes of matter, proves adequate to produce and to support for a limited period the ternary and quaternary compounds which we encounter in the bodies of living plants and animals.

§ 4. In consequence of the prevalence of ternary combinations in plants,

Oxygen, Hydrogen, Carbon	Vegetable compounds, Vegetable matter,

when they die they are obnoxious to decomposition; under the requisite conditions (access of air, the presence of moisture, and a certain degree of temperature) their constituents immediately begin to fall into the binary combinations of the inorganic world. This resolution of the vegetable elements takes place by three different but consequent processes of decomposition, — the *vinous*, the *acetic*, the *putrefactive fermentations.**

§ 5. The empire of the universal chemical laws is asserted in, if possible, a still more striking manner upon the matter of the dead animal body, with its elements made up of quaternary compounds, azote being added to the three principles already noted in vegetables.

Oxygen Hydrogen Carbon Azote	Animal matter, Animal combinations.

The two first forms of fermentation, if they be not entirely absent, are here so quickly accomplished, that, in general, they are not observed; and the putrefactive fermentation, which is due to the presence of the nitrogen, under favourable conditions, leads rapidly to the decomposition and change into binary compounds of all even the most solid of the highly animalised tissues. The reason of the slighter tendency to decomposition manifested by the less highly organised parts of the animal body, which are usually binary and ternary compounds, such as fat, the earthy portion of the bones (phosphate and carbonate of lime), and the horny tissues (in which azote is almost wanting), is obvious from what has already been said (§ 3.). On the same

* In the herbivorous animals we observe three corresponding and distinct digestive processes,—*ventricular digestion*, with the *vinous* or, rather, a stage preliminary to this, the *saccharine* fermentation; *small intestinal digestion*, with *acid* fermentation; and *great intestinal* digestion, with more or less of the *putrefactive* fermentation.

principles, it is easy to explain the more ready digestibility and more nutritive qualities of animal food, *i. e.* of quaternary organic compounds, than of articles taken from the vegetable kingdom, or ternary combinations. In the one case, a quaternary compound, viewing the animal body as an unit, is at work upon matter already akin to it; in the second, it is dealing with ternary combinations, which must have a fourth element added to them, and so be raised in the scale of organic compounds, before they can be assimilated and made fit to become a part of itself. In direct contrast to the horny and bony structures, stand the brain and nervous centres, which, as the softest, at once, and most highly animalised of all the organic structures, fall the most rapidly into putrefaction.

With the chemical decompounding processes, especially as they affect the animal body, *softening* and *liquefaction* are generally associated; in these respects, therefore, they stand in opposition to the formative powers of the organism, to the solidification of the elementary tissues out of fluids — out of the blood, for instance. *Coagulation,* as this solidification in its earliest stage is entitled, is exhibited in the formation of the crassamentum, as a kind of final manifestation of vitality by the blood; with the commencement of the chemical decomposition which ensues, the coagulated blood is resolved, it again becomes a fluid. Even so in the living animal body do we observe the same opposed tendencies: predominating plasticity, or disposition to coagulation and induration along with an excess, and colliquation or a tendency towards resolution and liquefaction along with a lack, of vital power.*

§ 6. The inorganic or binary, as well as the organic, combinations which are encountered in animal bodies, and produced under the influence of the vital power, present themselves in a variety of forms: amorphous, as gases, vapours, liquids; and with determinate forms, as solids.

Simple Chemical Constituents.

§ 7. Of the universally diffused simple elementary substances, the following have been found as constituents of animal bodies: — oxygen, hydrogen, carbon, azote, phosphorus, sulphur, chlorine, fluorine, scilica, potash, soda, lime, magnesia, iron, manganese. The carbon, sulphur, azote, and phosphorus, belong particularly to the organic kingdom of nature; the two latter, to the animal division of it.†

* In this consolidation of the plastic fibrine in the organic separation of the blood, and this resolution or liquefaction of the same element in its chemical decompositions, aided by the normal transudations, or endosmoses and exosmoses, lie the true conditions to nutrition and reproduction in general, viz. the animalisation or change of fluid blood into solid organised animal matter, and the *dis*animalisation and *re*liquefaction of the same matter, vanquished by the chemical affinities, to admit of its being resorbed and then removed from the economy.

† Perhaps it would be more correct to say that the carbon and sulphur are encountered in like abundance in the inorganic and in the organic kingdoms; that azote is an essential and most abundant ingredient of the atmosphere, as well as of most animal (fat, oil, spermaceti, cholesterine contain no azote) and many vegetable bodies; and that phosphorus is principally known as an element of the organic kingdom, particularly of its animal subdivision.

Compound Chemical Constituents.

(*A*) *Inorganic* (*binary*) *Combinations.*

§ 8. Water, carbonic acid, hydrochloric acid, sulphate of potash, chloride of potassium, sulpocyanide of potassium, sulphate of soda, carbonate of soda, chloride of sodium, carbonate and bicarbonate of ammonia, hydro-chlorate of ammonia, phosphate of lime, carbonate of lime, sulphate of lime, chloride of calcium, fluoride of calcium, carbonate of magnesia, phosphate of magnesia, scilica, oxide of iron, phosphate of iron, oxide of manganese.

(*B*) *Simple Substances in particular Combination with Animal Matters.*

Sulphur, phosphorus, iron.

(*C*) *Salts with Inorganic Bases and Organic or Animal Acids.*

§ 9. Lactate of potash, lactate of soda, lactate of ammonia, lactate of lime, lactate of magnesia, urate of soda, urate of ammonia, urobenzoate of soda, cholate of soda, sebate of soda, margarate of soda.

(*D*) *Animal Combinations.*

(*a*) *Quaternary.*

§ 10. Fibrine, albumen, gelatine, mucus, animal extractive soluble in alcohol (osmazome); animal extractive taken up by water (of flesh, of the tears, of saliva, of the crystalline lens, of the seminal fluid—spermatine); farther, urea, caseine, picromel, resin of the bile, lactic acid, uric acid, pigmentary matters — as of the blood, of the choroid coat of the eye, of the rete mucosum or epidermis, of the horny tissues, &c.

(*b*) *Ternary* (*Azote being absent*).

Sugar of milk, acetic acid, horny substance, and fat, which is a mixture of stearine and elaine.

OF THE INTERCHANGES AND GENERAL TRANSFORMATIONS OF ORGANIC MATTER.

§ 11. Three of the compound animal matters, — albumen, fibrin, and gelatin, in combination with water, play the most important parts in animal bodies; although in a state of purity, they possess peculiar properties, and, during life, have undoubtedly different imports, they are still so closely allied, that under the influence of the vital force, the one is readily changed into the other.* Fibrin seems to stand in the middle between albumen and gelatin, and to form a kind of transition step from the one to the other; it is consequently met with in the general or all-pervading fluids — the blood and the lymph — as a principal ingredient. As food, these three matters are also the most nutritious, and in the fluid state the most digestible.

* So are they, it would appear, readily convertible out of the body by means of certain chemical agents. M. Denis ("Essai sur l'Application de la Chimie à l'Etude Physiologique du Sang de l'Homme," 8vo. Paris, 1840) found that an artificial albumen could readily be produced by digesting coagulated fibrine in dilute solutions of many of the neutral salts, especially the chloride of sodium and the carbonates of the alkalies.

§ 12. Animal matters, in general, as also the various excretions of animal bodies, — the carbonic acid of the lungs and skin, the excrements, the urine, the mucus, &c. are appropriated by plants as nourishment, and in their systems undergo transformation into the various forms of vegetable matter we encounter; and plants, again, consumed by herbivorous animals, suffer transformation into new shapes, and become fitted to form constituent elements of their bodies. Here they remain for a time; but, decomposed at length, they are expelled, and again become a portion of the vegetable world; or, before decomposition, they are seized upon as food by some carnivorous creature, — man, quadruped, or worm, and made to serve for its subsistence. Organic matter, therefore, is in a perpetual round, passing from plants to animals, from animals to plants, and ever assuming new and appropriate forms. Vegetable matter, by the higher assimilating powers of animals, becomes animal matter, soon again to fall back and suffer degradation to the simpler shape of vegetable matter.

Formation of Solids from Fluids.

§ 13. Out of the fluid comes the solid, the shapen; all the parts of an animal body were once fluid, — they have all been formed from the blood; and after death they will revert to the fluid state again. Organic matter, itself engendered and developed under the influence of the vital force, forms with water a vivifying fluid of different kinds, either homogeneous and more or less consistent, or having numbers of extremely minute and regularly organised molecules mixed with it. This vivifying fluid has the faculty, according to the circumstances in which it is placed, of coagulating or solidifying in different ways. The organic matter that is the most highly endowed with vitality separates in a state more or less highly organised, appropriately fashioned and susceptible of life, ever in conformity with the vitality and character of that which is around it, and with or without the solid elementary particles with which it is mingled; it then gradually acquires distinct and individual forms, which always bear appropriate relationship to the structures amidst which the separation takes place.* In the same measure and degree as the plastic and living, but in itself, and as regards particular form, indifferent *blastema* (§ 31) is consolidated on the one hand, the medium of solution passes off or quits it on the other, until at length the organised matter and the water come to stand in mutual oppo-

* To this rule there are some remarkable exceptions. Besides the cartilaginiform, osseous, or earthy deposits, which are found in the fibrous parts, as age advances, many injuries are permanently repaired by a tissue, differing essentially from the one injured; and, in the course of the reparative process, temporary deposits often take place quite distinct in character from the structures in which they are formed. Numerous examples of both kinds might be cited. Fractures of the costal cartilages are commonly reunited by osseous matter. In fractures of the bones, whether of man or of the lower animals, if there be much displacement of the fragments, bony matter will be generally found deposited in the neighbouring soft parts, although this irregular deposit is not to be expected when the fragments have been properly adjusted, — a fact which may help to explain the discordant results obtained by different observers. According to my experience, when the broken portions of bone form an

sition. Such vital fluids, in reference to animal bodies, are the BLOOD and the LYMPH, the most universally distributed of all the fluids. From these all the solid parts of the animal body have been produced, by these they are maintained. It seems, therefore, essential that these primary, genetic fluids be particularly studied if we would hope to understand the mode of formation from them of the various animal fluids and solids.

OF THE FORMS IN WHICH THE CONSTITUENT ELEMENTS OF ANIMAL BODIES PRESENT THEMSELVES.

§ 14. The human and animal body, and indeed organised bodies generally, consist of FLUID and SOLID parts. The fluid constituents are divided into elastic, and inelastic or liquid ; the elastic fluids, again, are arranged into permanently elastic, or *gases*, and condensible fluids, or *vapours*. The solid constituents, in like manner, fall into two

angle, there is quite a distinct centre of ossification commencing in the soft parts that lie between the sides of that angle. This new bone being a provision to meet the exigences of an irregular case, I have ventured to term the *accidental callus*. It is, in fact, a separate point of ossification set up opposite to the broken ends of the bone, but at a distance from them, so as to facilitate the formation of a support between the fragments exactly in the most advantageous situation. The accidental callus, though for some time quite unconnected with the old bone, soon becomes united to the *regular callus*, the formation of the latter commencing between the periosteum and bone at a distance from the fractured extremities. For a figure of the accidental callus, see Drawings from the Anatomical Museum at Fort Pitt, fas. 3. pl. 9. fig. 6. and a notice in the "Edin. Med. and Surg. Journ." No. 129. — *G. G.*

grand divisions, according to their degree of consistency, and are spoken of as soft solids, or as hard solids; they are, also, sometimes classed in accordance with the degree of their organisation, and the peculiar forms they present, into simply solid constituents and solid fashioned constituents.

Of the Fluids.

§ 15. *Elastic Fluids.* In the healthy state gases are only met with in certain of the cavities and passages which are lined with a mucous membrane, in the windpipe and its subdivisions, and in the intestines. They always consist of different species mingled together, and, both as regards quality and quantity, are subject to perpetual variations, those in the lungs changing periodically and regularly, those in the intestines varying more accidentally and irregularly. The air of the atmosphere, which is taken into the lungs, consists, as is well known, of 79 parts of azotic gas, and of 21 parts of oxygen gas, with certain slight admixtures, particularly carbonic acid gas, vapours, dust, &c. which, with the exception of the carbonic acid, may all be regarded as more or less accidental. The carbonic acid, on the contrary, appears to be an essential ingredient in the atmosphere,—to be as necessary to vegetable as oxygen is to animal life. The gases and vapours of the intestines of animals generally consist of atmospheric air, with variable admixtures of carbonic acid gas, sulphuretted hydrogen gas, &c. Many of the fluids, and perchance even of the solids, contain combined gases in small quantity ;* the blood always contains a small proportion of combined air, consisting principally of carbonic acid gas.

Watery vapours mingled with gases only occur in the respiratory passages and alimentary canal, and upon the outer surface of the body. Their quantity generally bears a direct relation to the quantity and temperature of the gases with which they are mingled; still they vary considerably, and are always in smaller proportion under stronger than under weaker pressures; the air of the bowels in flatulence or tympanites, for instance, contains less watery vapour than the air of the lungs in ordinary respiration.

§ 16. *Liquids, Inelastic Fluids.* These consti-

* Dr. Davy made an interesting series of experiments with the view of ascertaining whether any gases could be obtained from various parts of the body. His general conclusion was, that the solids, excepting those — the lungs especially — which are designed to be its recipient, contain no air capable of being removed by the air-pump. M. Proust, M. Vogel, and Mr. Brande, have maintained, at different times, that carbonic acid is contained in the urine. From this fluid, however, in the state of health, Dr. Davy could obtain no air; and his numerous trials, with many of the secretions, gave the same result, with the exception of a single instance, in which a few minute spherules were procured from synovia, giving the idea of adventitious air entangled in the viscid fluid during the manipulation. As the results were perfectly negative in all his other experiments with synovia, as well as in those in which he opened the sheaths of tendons and the joints, with the requisite precautions, the statement of Laennec, that a small quantity of air is not uncommon in the synovial capsules, must be considered as requiring confirmation. — "Researches, Anatomical and Physiological," vol. ii. pp. 214–236. — *G. G.*

tute the *humours* or *fluids* of the body, properly so called, and both as regards the space they occupy and their weight, they exist in vastly larger proportion than the solids. The animal body always loses something like three-fourths of its weight by drying.* The fluids of animal bodies are always heterogeneous in their constitution. Their colour, the degree of fluidity they possess, and their other physical qualities, are as various as their chemical composition. The fluids, probably condensed in different degrees, form an essential element in all the solid parts of the body; or, otherwise, they are contained in particular reservoirs and vessels, through which they are carried in a circle to every part of the body for its growth and maintenance, and for the accomplishment of each and all of the important vital processes; or in which they are stored up till wanted for some particular purpose; or by which they are thrown out of the system as useless.

Among the humours or fluids of the body we distinguish, 1. Watery or serous fluids, in which variable quantities of organic and inorganic matters are held dissolved; 2. Oily fluids, — animal oils; and 3. Fluids of a mixed character, they being made up of the two former in different proportions.

* The entire dried body of an old woman, probably of seventy years of age, 5 feet 3 inches in height, preserved in one of the London museums, weighs no more than SEVEN POUNDS; it must have lost seven or eight tenths of its original weight by desiccation. Where there is the largest proportion of fat, the loss by drying is least; where there is little or no fat, as in the subject alluded to, there the loss is greatest.

§ 17. The *Serous*, or *Watery Fluids*, consist of water in which more or less of albumen and animal extractive, and various salts are dissolved. These fluids are diffused through the whole body; they enter as constituents into every one of the tissues, to which, in the main, they give volume, cohesion, softness, elasticity, colour, to a certain extent, and moistness, of course. They form, moreover, a very principal part of the general circulating fluids,—of the lymph and the blood, as the *liquor lymphæ et sanguinis*, the liquid element of the lymph and of the blood, and of all glandular secretions; they exist farther, in the transudations of all the serous cavities, in the interspaces of the cellular tissue, in the intestinal canal as the gastric juice and fluid of the intestines, and, with a larger proportion than usual of albumen, in all synovial cavities, sheaths of tendons, bursæ, &c., as synovia; finally they occur in the cavities of certain among the organs of sense, as in the watery fluid of the anterior and posterior chambers, and of the vitreous humour of the eye, in the labyrinth of the ear, as the aqua labyrinthi, and, lastly, in the fœtal envelopes, as the liquor amnii. The specific gravity of these serous fluids is always somewhat higher than that of distilled water, and varies, in proportion to the quantity of the solid matter held in solution, between 1·01 and 1·08. The watery fluids secreted by the glands, like the general circulating fluid, usually contain minute organised particles mingled with them; and, more than this, as in the spermatic fluid of the male, occasionally independent living animalcules, as essential elements.

§ 18. The *Oily Fluids*, or *Animal Oils*, are generally sluggishly fluent, and occur more isolatedly throughout the body. Their colour varies generally from a clear yellow to a green or a brown; occasionally they appear gray. Their degrees of transparency are very different; their specific gravities are not less so, varying between 0·8, and 0·94. In point of chemical composition they contain almost no oxygen, and but little azote. Their proximate elements, which are often separable by simple mechanical means, are fluid elaine, and solid stearine; the amount of the latter determines the degree of consistency possessed by fat. Oily fluid, or fat, is prepared and stored up for different ends: in the cellular tissue, where it is secreted by particular glands, it probably remains for the general uses of the economy, under peculiar circumtances; poured out upon the skin in the shape of sebaceous matter, it gives suppleness and softness to the common integument; shed upon the edges of the eyelids, and into the cavity of the external ear, it fulfils obvious and most useful purposes. Sometimes, again, we observe oily particles mechanically suspended in the fluids, as in the chyle, in milk, and now and then in the serum of the blood itself; or otherwise, we find it chemically combined with an alkali, as in the bile, or with one or other of the simple substances, sulphur, phosphorus, &c.

§ 19. A mixture of a watery fluid with fat, and other matters, forms the bile.

§ 20. Animal oil, mixed with watery fluid is found in chyle, in milk, in the yolk of the egg, in the blood, &c.

We shall by and by treat of the blood, the lymph, and the different fluids secreted by the glands, under particular and separate heads.

Of the Solids.

§ 21. The solid parts of the animal body are of various forms and composition. The elements of the solids, or simple textures of which they consist, by reason of their minuteness are only to be distinctly seen with the aid of optical instruments,—the single and double microscope. The form of the elementary solids depends either on physical and chemical forces, and then it is more or less accidental with reference to the body; or being highly organised, their form is then determined by the plastic powers of life, and is in harmony as well with the parts around them, as with the entire body of which they form constituents.

I.—UNORGANISED SOLID PARTS. *Fig.* 164–179.

§ 22. *Drops.*—*Fig.* 164–169. Fluids of different kinds when mixed together and left at rest, when no chemical affinity influences them, arrange themselves according to their specific gravity into superimposed layers. Agitation effects in the one or other of these fluids (generally in that which is the specifically lighter and smaller in quantity), a mechanical separation into small portions, which, in virtue of the force of cohesion, collect into globular drops. These drops are readily distinguishable scattered through the surrounding fluid, when their refractive power differs, as it very generally does differ, from that of the fluid. Globules of air in water or oil, of oil in water, &c., are perceived in virtue of the different refractive powers which they severally possess; and are distinguished from organic corpuscles suspended in fluids, such as granules, globules, discs and vesicles, first, by the great diversity they present in point of size, and secondly, by their complete transparency. If the fluid with which bubbles or drops are mingled, have a little mucilage, albumen, sugar, or any thing that will give it consistency, dissolved in it, the drops then remain distinct for a longer or shorter space of time; in the contrary case, should the suspending fluid be perfectly limpid, if left at rest, they speedily coalesce. In several of the animal fluids, other fluids are included in the form of drops—air in saliva, oil in milk (*fig.* 22) and in chyle (*fig.* 23).

§ 23. *Solid Precipitates.* *Fig.* 170–179.—All animal fluids contain several substances in a state of solution, as well organic and inorganic salts, as free alkalies and acids, and certain peculiar organic compounds, which occasionally separate as precipitates; at one time in virtue of purely chemical laws, at another, through the agency of others less known, of an organic or vital nature.

Inorganic precipitates take place:—

1. *In consequence of an absolute diminution in the quantity of the solvent medium* (which is generally water), and this may be brought about by (*a*) evaporation; by (*b*) penetration of other neigh-

bouring less fluid parts (imbibition and infiltration); (*c*) by absorption through the lymphatics and veins; or, (*d*) as a consequence of secretion, when the fluid separated contains a smaller quantity of matter dissolved than the fluid from which it was elaborated.

2. *In consequence of Changes produced by Admixture*, (*a*) as when in consequence of a change effected in the solvent by a new substance, it becomes incapable of holding one of its old ingredients in solution; (*b*) when under the same circumstances a new product is formed which is insoluble; (*c*) and when the products of double elective affinities, though not insoluble, require more fluid to dissolve them than is present; in this case a portion of the least soluble necessarily separates in the solid form.

§ 24. Inorganic deposits occurring in the animal body frequently contain organic matters mingled with them: gall-stones contain cholesterine, urinary calculi and gouty concretions contain uric acid, mucus, &c. Organic matters occurring under such circumstances, however, never present any of the appropriate forms or particular characters of organisation; on the contrary, they are either crystalline, or have their forms impressed upon them by mechanical contact or attrition. They may be aptly divided according to their forms, into 1. crystals; 2. rolled gravel; 3. granular gravel; and 4. accidentally fashioned larger concretions.

§ 25. *Crystals* (*fig.* 170–176.) These are bounded by determinate planes, angles, and edges. Crystals are encountered by no means unfrequently in the bodies of men and animals, but only very rarely as normal constituents; crystals, however, do occur in the labyrinth of the ear. They are much more common in the fluids of the different secretions, as in the liquor amnii (*fig.* 30, B.); in the various forms of morbid fluid deposits especially, and occasionally also in the intimate tissues of parts, as in the plexus choroides of the lateral ventricles, the pineal gland, &c. (*fig.* 30, A.) The forms of crystals are often indifferently characterised, and then they pass by insensible degrees into calculi or gravel; this is the case as regards the sandy particles of the pineal gland and choroid plexus, and the crystals of stearine (*fig.* 31, D.)

Crystals arise in the animal body under the same circumstances, and in obedience to the same laws, as they do out of it, viz., by the gradual abstraction of the conditions under which the crystallisable matter is rendered soluble, or is held dissolved; they are, in fact, always either salts, or compound bodies analogous to salts, never simple substances, acids, oxides, or bases. Lamelliform and foliaceous crystals are easily distinguishable from organised squamæ and lamellæ, in their total want of every indication of organic formation.

§ 26. *Rolled Gravel* (*figs.* 29 and 177.) I thus entitle those small, globular, hard, inorganic deposits which owe their form, like the gravel of the beds of rivers, to their motion and mutual attrition. The globular gravel voided from the bladder [and renal pelvis?] by the solidungula and man, and the rounded concretions so often met with in the gall-bladder, may serve as examples of this form of deposit. It may have been originally crystalline, or it may, and frequently does, contain a crystalline nucleus; I have only encountered this rolled gravel in mucous cavities, and in the larger excretory ducts. Similar formations, which receive their shape from the minute cavities in which they are produced without rolling or rubbing, for example, the concretions from mucous crypts, do not belong to the present category, but might be described apart, under the title of *concrete gravel.*

§ 27. *Granular Gravel, Grit, or Sand* (*fig.* 178). This occurs in the shape of small, hard, irregularly rounded, inorganic masses, of a reddish, grayish, or whitish colour, which still bear traces of their original forms, as irregular or imperfect crystals, with the angles and edges worn away. This kind of grit is therefore intermediate to the smallest perfectly crystalline precipitates and rolled gravel. It is, in fact, frequently found mingled with entire crystals, and with masses that have undergone attrition, and had secondary deposits let fall upon them in every degree. Such grit, or granular deposit, besides being met with in the renal and subordinate system, where it occurs very frequently, is also occasionally seen as an abnormal product upon the surface of serous, more rarely upon that of synovial, membranes, as on the pia mater of the brain, on the pleura, peritoneum, omentum, and tunica vaginalis testis; also in abnormal cavities, in cysts containing watery fluids, &c. In point of chemical composition, this kind of gravel differs essentially, according to the situation in which it is deposited.

§ 28. *Mulberry Gravel* (*fig.* 179) occurs in the shape of agglomerated masses of grit, or small rolled gravelly particles, and is very generally found associated with simple grit, and with rolled gravel; this occurs in the renal pelvis of man and of the horse (*fig.* 29, B.) It is met with only in cavities lined with mucous membranes, and is either a morbid product of the multilocular or racemiform mucous glands, from which it then derives its form, or it acquires its irregular acinular shape by deposition in some unknown way. The best specimens of this mulberry-like, or agglomerated gravel, are probably met with in the biliary ducts and reservoir.

§ 29. *Accidental, mechanically formed* (*not microscopic*) *Concretions.* Besides the microscopic concretions now described, other accidental inorganic deposits are occasionally met with in the animal body, and generally in cavities lined with a mucous membrane, which derive their forms from the surrounding structures with which they are in contact, or which repeat, on a larger scale, the forms that are encountered in the different kinds of gravel on a smaller scale. To this category belong, gall-stones, urinary calculi, intestinal calculi, salivary calculi, lachrymal calculi, &c. When these inorganic matters are produced within one of the smaller cavities of the body, and continue to grow there till they fill it, they at length come out more or less perfect moulds of the receptacles or canals where they were engendered. In this way, urinary concretions are met with that are accurate casts of the pelvis of the kidney; biliary calculi, that figure the shape of the gall-bladder precisely; dacryoliths, that have the form of the lachrymal canal and its two afferent ducts; salivary calculi, that are long and cylindrical, and even branched like a mass of coral, from having penetrated into the excretory ducts of the gland which prepared the fluid whence they were precipitated. When several concretions are formed in any of the situations indicated, they then acquire polyhedral and irregular forms, with rounded angles and corners, in consequence of their mutual contact and attrition: such forms are particularly common in the concretions of the gall and urinary bladder. When they occur singly, they generally present the figure of flattened ellipsoids; this is by much the most frequent form of urinary calculi. They are also commonly enough globular in form—the intestinal concretions of the horse, and other lower animals, are almost always round. The cause of the extremly regular form often presented by calculous concretions of the mulberry and other kinds, when this can neither be traced to the influence of crystallisation, nor of mechanical attrition, is less known. Finally, we now and then meet with a concretion that might, with some propriety, be spoken of as a single large crystal; this is especially the case as regards some biliary calculi.

The whole of the concretions which are found in mucous cavities, consist of the chemical constituents of the fluids by which they are surrounded; but they also occasionally contain principles derived from the mucous membrane. The normal and constant concretions of the living body, are the crystals of the labyrinth of the ear, the granules of the pineal gland and choroid plexus, the globular gravel of the urine of the solidungula, and the crystals of the liquor amnii. All the other inorganic precipitates are to be viewed as the accidental products of abnormal or morbid conditions.

II.—IMPERFECTLY ORGANISED CONSTITUENT ELEMENTS.

Amorphous Solid Constituents; Organic uniting Media — the Hyaline or Vitreous Substance (fig. 57 a, 61 a, 65 a; also fig. 243–249.)

§ 30. The hyaline or vitreous substance, forms a considerable constituent element in the animal body. Although amorphous in itself, it must still be associated with the organic parts, inasmuch as it is formed cotemporaneously with other more highly organised elements, as it stands in a certain relationship to these, and for its maintenance requires, like them, a perpetual interchange of substance. The vitreous element is translucent in every degree to perfect transparency; it is colourless, or but slightly tinged; generally it is of firm consistence, and highly elastic. It serves as a transparent medium for optical purposes, as in the crystalline lens of the eye; as a protecting and sheathing medium, as in the Whartonian pulp of the umbilical cord; or as an elastic bond of union, —as an intercellular substance, for instance, in the cell-including vitreous matter of cellular cartilage, in the cartilage of the bones, and in the canalicular or tubular structure of the teeth.

III. — MORE HIGHLY ORGANISED CONSTITUENTS.

Morphic Organic Constituents (*fig.* 180–238).

§ 31. *Fibrine.* — The fibrine which is held dissolved in the serum of the blood and of the lymph, may be regarded as the general formative element or blastema — that principle which, under the influence of the primary and secondary organic processes, is fitted to assume all the shapes which we observe in the constituent parts of animal bodies. Fibrine left at rest, consolidates, under all circumstances short of those which act by decomposing it, first, into a determinate hyaline substance, which in the greatly debilitated and in the dead body, and also out of the body when left to itself, falls into granules, or forms an aggregated granular mass.* Plastic fibrine has, therefore, in its

* The softening of fibrine in the living body constitutes a distinct elementary disease of much interest, as well from its frequency as from its connexion with the prevailing doctrines about suppuration. M. Gendrin instanced mere softened clots of fibrine as cases of suppuration — transformations of fibrine into pus — and this view has since been generally adopted and promulgated in this country. Yet M. Gendrin also maintained that suppuration was a metamorphosis of the blood corpuscles; thus confounding, as Mr. Palmer remarks, two distinct and well-known constituents of the blood. Dr. Young had long previously stated his opinion, that the globules in pus are the globules of blood somewhat altered in suppuration. — *Medical Literature*, 8vo. Lond. 1813, p. 509.

In an inquiry, which I undertook with a view of ascertaining morphic changes, two forms in common with other coagulating matters — viz. the form of a vitreous substance, and that of granules. In animal oils, we already observe the formation of

the constitution of pus, and of some other fluids with which it may be confounded, it appeared, that the liquid or pulpy matter in the centre of fibrinous clots, was totally distinct from pus, and that the *softening of fibrine* had been improperly confounded with suppuration. Besides its proneness to putrefaction, softened fibrine differs in some other chemical properties from pus; and the characteristic globules of the latter are either wanting in the former, or not in sufficient quantity to render the matter identical with pus. The mass of the softened fibrine, in short, is made up of a very minutely granular substance, frequently with some very irregular flaky particles — the globules which it often, and indeed generally, contains forming but a small proportion to the other materials; whereas, the globules of pus constitute the bulk of the particles visible by the microscope.— *Vide* "Transactions Roy. Med. Chir. Soc." vol. xxii.

Probably, no subject in physiology is of more importance than the nature of fibrine; and its structure and varieties, and the changes to which it is liable, are of the highest interest to pathological science. It appears to me, that a precise inquiry in this department is still wanting; and that when completed, it must afford some valuable results. I am, therefore, induced to add, very briefly, an account of a few observations which I have made on fibrinous clots, with the hope of directing attention to this interesting field of research.

Of the fibrinous exudations so frequently resulting from inflammation, the structure agrees with the description of the author; to which, however, it should be added, that besides the transparent matrix and the globules, a most minutely granular matter pervades the mass. The globules resemble those of pus in size; and are, in fact, identical with those floating in the contiguous sero-purulent matter. At an early stage, they seem very granular on the surface and loose in texture, as if the globule were composed by the mere approximation of granules, on a loss of temperature. This, however, cannot be regarded in any other light than as an imperfect process of crystallisation; — the precipitated granules of stearine are imperfect

numerous granules. At a more advanced period, the globules have a more dense or compact appearance. Fig. 243 represents a portion of coagulated lymph, magnified about 380 diameters, from a case of traumatic inflammation of the peritoneum in the horse; the globules are held together by a hyaline matrix, and very delicate granular particles pervade the mass. From the microscopic characters, therefore, the term concrete pus, by which the French pathologists designate the fibrinous clots found within inflamed serous sacs, would not seem less applicable to this matter than the appellation of Hunter — coagulated lymph. But these exudations are more or less firm — completely preserving their integrity, however agitated with water; whereas, there is a very common variety, generally co-existent with the other, also concrete, but most readily miscible with water. The difference seems to be, that one is a congeries of globules kept together merely by a little serous moisture, while the other is a coagulum of lymph pervaded by similar globules; that the latter is the medium for a higher organisation, of which, as far as we at present know, the former is not susceptible. The microscopic and chemical characters of the globules are nearly, if not quite, identical in both varieties; that miscible with water, is most frequently found in dependent parts of the inflamed sac, in consequence, simply, of a subsidence of the globules which form the mass.

The structure, then, of the fibrinous exudations, resulting from inflammation, is so far complex, that we find globules connected together by a transparent clot of lymph, which is most frequently pervaded by exceedingly minute granules. Indeed, the opacity and colour of the whitish false membrane is mainly due to the great number of globules and granules it includes.

Although the appearance of an aggregated granular mass is common, yet that fibrine, left at rest, always consolidates, as mentioned in the text, into a determinate hyaline or granular sub-crystals (*fig*. 31 *d*). Albumen, which is a more highly assimilated substance, is susceptible of taking both forms. When albumen sets gradually either within or without the body, organic granules

stance, is not in accordance with my experience. Sometimes, the ultimate texture of a portion of fibrine appears to be made up of fibrils of extreme tenuity, often parallel, but with frequent interlacings, and constituting a microscopic web, much finer than even that of cellular tissue. Fig. 244 exhibits a portion of a very firm clot from the heart of a child, about twenty-four hours after death. Fig. 245 represents another part of the same clot, with an obscure appearance of globular bodies in the interstices of the fibrils. Both preparations are magnified about 700 diameters, after being spread out with needles, which it seems right to mention, as a filamentous appearance might be referred, and perhaps justly, to this mode of extending a homogeneous substance. The fibrils, however, are often better seen, without any extension or stretching, in a thin slice from a clot rendered hard by boiling, as in Fig. 247. In many instances, the fibrils are infinitely shorter than here represented, and so arranged as to form a kind of areolar tissue, of a delicacy so exquisite, that the best glasses and manipulation are required to bring it into view: often, the areolar disposition is less perfect, and the extremely short and fine filaments are connected by transverse fibrils. In either case, the interspaces of the delicate frame-work seem to be filled with the fibrinous pulp, either quite homogeneous or pervaded by most minute molecules. The disposition of the fibrils in the varieties here mentioned may often be best seen at the edges of the thinnest slices taken from portions of fibrine made hard by heat.

In fibrine which has clotted simply by being left at rest, either in the body after death, or in blood removed from the vessels during life, I have found simple and compound corpuscles, which must probably be regarded as organic germs, very commonly about $\frac{1}{2700}$th of an English inch in diameter, although very variable in magnitude. These corpuscles are interesting in many respects, whatever opinion may be formed of their nature. They must either have existed in the circulation, or are formed, which are capable of no higher organisation. When albumen sets quickly, it forms a coherent mass, which however shews no trace of organisation, and cannot therefore be likened to

been formed during the coagulation of the blood, quite independently of the influence of the living tissues. Fig. 246 represents these corpuscles in some fibrine, obtained by whipping from the blood of a horse. The animal, which is now at work, was bled in consequence of swelling of one of the hind legs—an affection to which he is liable; the attack was of fourteen days' duration: there had been some inflammatory fever, which appeared to be subsiding. Fig. 247 shews the corpuscles more distinctly; and contained in an extremely delicate web of fibrils — the fibrine was obtained from the same blood, and rendered firm by boiling, so as to allow of a thin slice being made, from which the drawing was taken. Fig. 248 exhibits the same corpuscles after being subjected to the action of acetic acid, from which their envelopes are swoln a little, and rendered sufficiently transparent to shew the nuclei which they inclose. If the acid be in excess, or very strong, or left a few minutes in contact with the corpuscles, the envelopes will often disappear entirely. The three last figures are magnified nearly 700 diameters.

Sometimes, the corpuscles are destitute of nuclei — at least, none can be discovered by the aid of the ordinary re-agents — in which case, the corpuscles give the idea of a kind of corrugated capsule, or empty cell, as shewn in Fig. 249, which was drawn from a portion of a fibrinous clot obtained from the heart of a child, aged two months, which died of disease of the mesenteric glands and diarrhœa. I am indebted to the kindness of Dr. Boyd for an opportunity of making this examination. The magnifying power employed was 800 diameters.

The size of the nuclei is very variable; but the $\frac{1}{8000}$th of an inch is a diameter very commonly seen among them, as is also the $\frac{1}{6000}$th, and even the $\frac{1}{5000}$th. They may probably precede the envelopes in formation; for in many cases the nuclei are instantly brought into view when the fibrine is made transparent by acids, although no appearance whatever of the hyaline substance. The fibrine of the blood, however, in setting, even when abstracted from the body, forms a true hyaline substance, which encloses the blood globules, precisely as that of car-

envelopes can be seen, however carefully the action of the re-agents is watched.

The action of sulphurous acid in rendering the matrix quite translucent, and in giving a very definite outline to the nuclei, is remarkable. In many instances in which the fibrine, however carefully examined, presented only an amorphous or aggregated granular appearance, the sulphurous acid exposed the nuclei most clearly, as in fig. 250. In some cases the cells or envelopes are very faint, as if in progress of formation, as shewn in fig. 251, while the nuclei are apparently completely mature. Both figures were made after fibrine obtained from the blood of the horse, removed during the life of the animal. By the aid of the sulphurous acid, I have also found the corpuscles abundantly in fibrinous clots obtained from the portal, and splenic, and pulmonary veins.

The nuclei, thus shewn naked, are mostly rather irregular in shape, generally nearly round, and not uncommonly oblong, as if extending by growth. Sometimes they are not numerous, though very distinct; frequently they are most abundant, and not uncommonly larger than above indicated. In a clot of fibrine from the portal vein of a woman, aged eighty-two, who died of pneumonia, they were from $\frac{1}{6000}$th to $\frac{1}{4000}$th of an inch in diameter; and in a clot from the heart of a man, aged thirty-one, who died of sphacelus and suppuration, they were in vast numbers, and of about the same size. But in neither of these cases could the particles be clearly seen without the aid of an acid; though, with it, they became remarkably definite and characteristic. Tartaric, oxalic, sulphurous, and acetic acids may be employed.

In a few instances, true cells may be seen; that is, cysts three or four times the size of the corpuscles, and capable of containing the latter as nuclei. It, however, so rarely happens that the corpuscles are thus inclosed, that no unequivocal instance of this was observed, although the cells, as mentioned above, were not very unfrequent, and either shrivelled or more tilage encloses the cartilage corpuscles: when it coagulates in contact with the interior of the living body, immediately higher organic processes are proclaimed in the formation of compound corpus-

or less filled with granular matter. Sometimes, also, corpuscles were observed of a very different character, these being made up of pretty well defined spherules, between $\frac{1}{12000}$th and $\frac{1}{8000}$th of an inch in diameter. The compound corpuscle thus formed is generally round or oval, and about $\frac{1}{2000}$th of an inch in diameter.

The corpuscles previously described may be sometimes found together in great abundance in one part of a clot, when the most diligent search is unable to detect them in another part not many lines removed; and many clots may be examined without finding any of the corpuscles. Mr. Siddall and I found them in some fibrine, obtained by whipping, from the blood of a pregnant woman, but we could not detect them in the same fibrine two days subsequently. It may be suggested, that the corpuscles are the blood disks, entangled in the fibrine, although none of the colouring matter be visible. If so, the disks must have undergone remarkable alterations in size and figure, as well as in chemical properties. But this question comprehends a variety of considerations, which it is unnecessary to discuss here. — See Dr. Barry's observations, "Phil. Trans." Part II. 1840.

It may not be improper to remark, that the terms *granules* and *granular* seem to be employed in the text to denote an assemblage of most minute molecules, and that they are used in the foregoing note in the same sense. Granules are generally smaller than $\frac{1}{12000}$th of an inch in diameter, and in other respects utterly different from the corpuscles which have just been described. These latter are analogous in size, shape, and structure, to the primary cells of Schwann and Henle, and to the nucleated nuclei of Valentin, and appear to be the same as the fibrinous globules of M. Mandl, which he describes as forming, by coagulation, on the object-glass of the microscope. He says, that the fibrine of the frog, when separated by filtration from the blood-disks, is full of these white fibrinous globules, — a statement, however, at variance with the observation of Müller, that this fibrine is without corpuscles, and quite homocles, which either swim free in the fluid, as the globules do in the blood; or they appear as isolated bodies disseminated through a hyaline substance, or variously arranged without any common bond of union, and so attain their final developement; or they present themselves as mere transition forms of more highly organised products, which, with the final completion of the developement, disappear entirely. These corpuscles are, in fact, the primary types of all higher formations in vegetable as well as in animal bodies; they are, as it were, the universal organised condensations of the living plastic fluids. The vegetable corpuscles have been named by Brown AREOLÆ, and by Schleiden, CYTOBLASTS (CELL-GERMS). There can be no objection to the extension of these titles to the nucleolated nuclei of the animal kingdom; and I shall constantly speak of these nucleolated nuclei under the name of *cell-germs* or *encased nucleoli*.

§ 32. In animal bodies, two classes of solid precipitates from vital fluids may be distinguished, each of which has a different organic signification:

geneous ("Physiology," by Dr. Baly, second ed. Part I. p. 124). Though M. Mandl saw "perfect purulent globules" in some delicate fibrinous shreds, separated by rods from blood diluted with white-of-egg, he found clots of pure fibrine, too compact to be examined successfully with the microscope. He considers the white globules of the blood, the globules of pus, of mucus, and those of the secretions, as identical. — "Anatomie Microscopique," Liv. i. et ii.

I was unacquaintad with M. Mandl's ingenious observations till some time after the foregoing note was printed. It will be seen, that my results having been obtained by the examination of compact masses of fibrine, either with or without the assistance of chemical agents, were arrived at by a different method

Some are *Objective, i. e.* they form no immediate integral part, essential to the life of the organisation ; and others are *Subjective, i. e.* they form immediate, original, and indispensably necessary parts of the body ; in other words, we have *aplastic* elements —elements susceptible of no farther amount of organisation, and *plastic* elements—elements which bear within them the germs of higher forms. Each of these classes of elements forms two orders ; the objective or aplastic fall into, 1. *inorganic crystalline*, and, 2. *semiorganic, noncrystalline, mechanically fashioned.* The inherently vital cell-germs again divide themselves into (*a*) *monoplastic*, which retain their primary forms and, (*b*) *polyplastic*, which lose their primary shapes, transform themselves into all the organic forms, and, in fact, are destined to one that is higher. The opposite table is intended to convey an idea of these various relations, and at the same time to afford a compendious survey of the organization and evolution of the elements of animal bodies out of the cell-germ or encased nucleolus. *See Table.*

from that pursued by M. Mandl ; and while he rejects the idea of nuclei, I have often seen them in great numbers, without any envelopes, as in fig. 250 ; and, indeed, that I am led to regard the corpuscles as organic germs, or primary cells, almost always with the characteristic nuclei, although these seemed to be absent in some instances, as in fig. 249. The conclusion of M. Mandl, that the fibrinous globules are simply the result of coagulation, is not supported by the fact, that white globules, precisely similar to those in the blood of the frog, may be seen circulating in the veins of the animal, moving very slowly along the inner tunic of the vessel, and often dropping into the central current of blood-disks, and liquor sanguinis, and then passing with velocity onwards.

PRECIPITATES FROM THE FLUIDS IN THE LIVING HUMAN AND ANIMAL BODY, AND DEVELOPEMENT OF THOSE THAT ARE ORGANISED.

- **Formations unsusceptible of independent Organisation.**
  - **Unorganised.** — MIXTURES OF ORGANIC WITH INORGANIC MATTERS.
    - CRYSTALS. Chemical Forms:
      - Crystalline Elementary Forms.
        - Tetrahedron.
        - Octohedron.
        - Triangular Dodecahedron.
        - Paralellopiped.
        - Six-sided Column.
        - Rhomboidal Dodecahedron.
    - CONCRETIONS. Mechanical Forms:
      - Microscopic Concretions.
        - Grit, Sand, Gravel.
        - Rolled Gravel.
        - Mulberry Gravel.
        - Grit of the Mucous Follicles.
      - Larger Concretions. Calculi, Stones.
        - Lachrymal Concretions.
        - Salivary Concretions.
        - Intestinal Concretions.
        - Biliary Calculi: ——of the Gall-bladder. ——of the Gall-ducts.
        - Urinary Calculi: ——of the Kidney, or Renal Calculi. ——of the Ureter. ——of the Bladder.
        - Uterine Concretions.
        - Vaginal Concretions.
  - **Partly Organised, but always incapable of further Developement.** — ALBUMEN.
    - COAGULUM. Organic Forms:
      - Granules.
      - Aggregation Granules or Globules.
      - Granular Fibres.
      - Granular Membranes.
      - Flocculi, Flocks.
- **Formations capable of independent Organisation and farther Evolution.**
  - **Organised, capable of peculiar Organisation.** — FIBRINE (Vitalised Albumen.)
    - CYTOBLAST, CELL OR ORGANIC-GERM, CASED OR NUCLEOLATED NUCLEUS. Organic Forms:
      - Enduring Cell-germs.
        - Lymph Corpuscle.
        - Blood Corpuscle.
      - Degenerating Cell-germs.
        - Ichor Corpuscle.
      - Partly Degenerating, partly Progressive Cell-germs.
        - Exudation Corpuscle.
          - Retrograding: Pus Corpuscles.
          - Advancing in Developement: CELLS.
            - Retrograding and Vanishing Cells, but leaving behind them Organised Cellular Substance.
              - Filamentous Intercellular Substance.
                - Fibrous Rete.
                - Elastic Tissue.
              - Hollow Intercellular Substance.
                - Hollow Fibrous Rete.
                - Capillary Vascular Rete.
            - Permanent Cells.
              - Isolated. Vitreous Substances.
                - Cartilage Cells. — In Cellular Cartilage.
                - Bone Cells. — In the Bones.
              - Aggregated.
                - Ganglion Cells.
                  - Ganglionic Globules.
                  - Gray Central Substance.
              - Arranged in Rows.
                - Cellular Indusiæ: Epidermis, Epithelium.
                  - Non-ciliate. — Tessellate Epithelium.
                  - Ciliate. — Ciliate Epithelium.
            - Progressive Cells.
              - Cellular Fibres.
              - Ovum.
                - Enduring.
                  - Non-ciliary.
                    - Varicose Separating Fibres of the Soft Nerves and delicate Vessels.
                    - Non-Ciliate Epithelial Cylinders.
                  - Ciliary.
                    - Ciliary many-nucleated Epithelial Cylinders.
                - Progressive, Becoming changed into fibres.
                  - Flat Fibres.
                    - Spiral Fibres.
                    - Wrapping Fibres.
                  - Hollow Fibres.
                    - Primary Fibre of Nerves.
                    - Uriniferous Tubes.
                    - Seminiferous Tubes.
                    - Tubuli of the Teeth.
                  - Round Fibres.
                    - Cellular Fibres.
                      - Synovial Membrane.
                      - Serous Membrane.
                      - Connecting Cellular Tissue.
                      - Investing Cellular Tissue.
                    - Tendinous Fibre.
                      - Tendons.
                      - Tendinous Fasciæ.
                    - Ligamentous Fibre.
                      - Of the Ligaments.
                    - Cartilage Fibre.
                      - Of all the Fibrous Cartilages.
                    - Contractile Fibre.
                      - Of the Iris.
                      - Of the Integument, especially of the Scrotum &c.
                    - Muscular Fibre.
                      - (a) Of the Muscle of Organic Life.
                      - (b) Of the Muscle of Animal Life.

§ 33. *Organic Granules; granular Coagulum.* The precipitate of extremely minute, soft, organic granules, so universally encountered in the animal body, appears for the most part to consist of albumen. These granules would seem only to form cell-germs, or nucleolated nuclei, when the coagulation of the fibrine takes place otherwise than in vital association with the internal structures of the individual who engenders it. There is scarcely a watery or mixed animal fluid without its granules: wherever albumen in solution is met with, there will granules be discovered. These granules, however, are not always easy to be perceived: bright illumination and sharp definition, without which microscopical researches into the nature of transparent elementary parts particularly, are of little value, are here indispensable. In the chyle, so long as it is contained in vessels beyond the mesenteric glands, granules only, from the $\frac{1}{500}$th to the $\frac{1}{400}$th of a line in diameter, and oily globules,* are discovered; but after the fluid has passed through these glands, and has reached the central vessel of the lymphatic system, it begins, in addition to these, to contain cell-germs (lymph-corpuscles). Aggregated mucus-globules (*fig.* 25) (not epithelial cells), occur without admixture of cell-germs, because the secretion is too poor in fibrine; on the contrary, in all transudations of the liquor sanguinis upon internal surfaces, or into the tissues themselves, encased nucleoli (exudation-globules), are produced. Wher-

* These are generally from four to fifteen times larger than the granules.

ever the cell-germs perish, we also remark a retrograde tendency to the formation of granules: from the exudation globule, we have the granular pus-globule, which, in its turn, and very speedily, may fall into its elementary granules. The embryonic cells, and the last formed epithelial cells, which are in immediate contact with the corium, are almost completely transparent, without any trace of granulation; those that are cast loose, however, those of the lining membrane of the mouth, for example, are always granulated.

§ 34. Caseine, which bears so close an affinity to albumen, comports itself precisely like this substance; and, under the circumstances specified, like fibrine. The granular coagulum of diseased milk (*fig.* 23), cannot be confounded with the oil-globules of the fresh and healthy fluid (*fig.* 22).

§ 35. Granules are frequently seen collected into heaps or masses — *aggregation corpuscles** (*fig.* 190) — of different sizes, and either globular, ovoidal, or ellipsoidal in figure. The elementary granules are here held together by a fluid, and separate when this is attenuated in any way, as by the addition of water, in which the corpuscles dissolve without leaving nuclei behind them. They are produced in small cavities — the mucus-corpuscles (*fig.* 25, B) of the mucous crypts,† for instance,

* I entitle all compound, rounded, isolated particles — globules, ellipsoids, discs, lamellæ, &c. — which enclose a nucleus, and consist of aggregated granules, CORPUSCLES; and when the nuclei include others (nucleoli), I call them CELLS.

† Let a little piece of mucous membrane be washed with distilled water, by means of a soft hair pencil, all pressure being

or in unknown ways — the granular corpuscles, for example, which are often to be perceived with the naked eye in cysts with serous contents, and the granular pigmentary corpuscles (*fig.* 32, 1, *a*) of the pigmentum nigrum.

§ 36. When granules unite in rows like strings of beads, we have *granular fibres** (*fig.* 189) produced: several granular fibres lying in parallel apposition, form a granular fibrous *cord*, when this on a section appears cylindrical; when it is not cylindrical, but flat in different degrees, it forms a granular fibrous *bundle* or *fasciculus* (*fig.* 191). When the fibres run in two directions, extending at the same time in breadth, they form a *granular membrane* (*fig.* 192).

§ 37. The number of granules present never bears any kind of ratio to the quantity of albumen in solution; so that a fluid which contains albumen in the proportion of fourteen, may present no more granules than one which contains albumen in no higher a proportion than one. The nucleus of a cell-germ, the nucleolus of a nucleated cell, often exhibits the precise appearance of a granule,

avoided; let the surface be gently dried by means of a clean napkin; now fold the piece of membrane with the mucous surface outwards, and press it gently between the finger and thumb near and towards the folded edge. A little pure mucus will exude; and this being transferred to the stage of the microscope, between two fine plates of glass, the mucus-corpuscles will be seen in their highest perfection.

* I designate as *fibres* all elongated formations, the sections of which, within short distances, present differences in form or size: other linear formations I incline to call *filaments;* and these are divided into cylindrical, flat, prismatic, and hollow.

but it can never be confounded with this, nor ought it ever to be spoken of as synonymous with a formation of so much lower significance.

IV.—COMPLETELY ORGANIZED CONSTITUENT ELEMENTS — PARTS ENDOWED WITH INHERENT LIFE AND CAPABLE OF PECULIAR EVOLUTION.

§ 38. *Cell-germ, encased Nucleus* (*Cytoblast Schleiden*). This formation had long been known as an essential and general constituent in the structure of vegetables; but Schleiden* was the first (1838) who pointed out its significance in general, and especially in reference to the process of developement in vegetables; Valentin † and Schwann ‡ subsequently (1839) shewed its identity, both in structure and office, with the cell-germ of animals.

§ 39. The cell-germ of the animal organism accords so closely with that of the vegetable, that Schleiden's description of the latter might be applied in almost every particular to the former.

§ 40. The cell-germ of animals is, in the beginning, a globular, and by and by, a lenticular, or cake-like corpuscle, of a yellowish white or dull red colour, which encloses a nucleus, and is per-

* Beiträge zur Phytogenesis (Researches on the Formation of Vegetables), in Müller's Archiv. 1838, S. 137.

† Entwickelungsgeschichte; *vide* "Elements of Physiology" of R. Wagner, trans. by R. Willis, p. 214.

‡ Mikroscopische Untersuchungen, &c. (Microscopical Inquiries into the Similarity in the Structure and Mode of Growth of Animals and Vegetables). *Berlin*, 1839.

petually produced in the shape of an organic precipitate in the fibrinous vital fluids—the blood and the lymph. The dimensions of the cell-germ are different in different mammals, and under different circumstances in the same mammal (from the $\frac{1}{400}$th to the $\frac{1}{320}$th of a line in diameter), and it bears a general relation to the size of the blood globules of the individual;* its specific gravity is always greater the older it is, and this only de-

* If so, it would be a remarkable fact in favour of the views of Dr. Barry, that the blood disks are transformed into cells. ("Phil. Trans." Part II. 1840.) Schwann regards the red particles of the blood, the lymph globules, and the globules of pus and mucus, as isolated cells. ("Muller's Physiology" by Dr. Baly. Part I., second edition, page 399.) In a series of observations which I made on the pus of various mammiferous animals, there did not appear to be any general relation between the size of the pus and that of the blood corpuscle of the same animal; and in the Vicugna and Paco, which have oval red particles, the pus globules presented no peculiarity, being in form and size like those of many other animals. ("On the Blood Corpuscles and Pus Globules of certain Animals."—Trans. Roy. Med. Chir. Soc., vol. xxiii.)

Having discovered that the blood disks of the Napu musk-deer (*Moschus Javanicus, Pallas*) were much smaller than any previously described in the vertebrate animals, I examined the lymph globules of this little ruminant, and found them of about the same size as in the human subject. In the blood of the Napu musk deer, many of the large white globules were observed scarcely differing from those found in other mammalia, thus forming a striking contrast to the singularly minute blood corpuscles. Nuclei were often seen in the white globules. In the blood of reptiles and birds, these globules are common; but they are much of the same form and size as in mammiferous animals, notwithstanding the great differences between the blood clines when it is again dissolved.* When the cell-germ is observed, whilst lying flat or on its side, its outline appears now round, and again elliptical; and when many cell-germs are produced, and they

corpuscles. Mr. Lane's observations are to the same effect. ("Lancet," 1840, p. 121.) I find that the mucus-globules obtained from the mouth of a frog do not exceed in size those from the same part in the human subject; and this observation applies to the cells of the epithelium, which were examined at the same time.—*G. G.*

* The determination of the specific gravity of the microscopic constituents of animal bodies is important, both as regards the chemical and the organic analysis of these, inasmuch as it might frequently serve as a means of distinction between them: but it is at all times difficult to come to conclusions; and when we have to deal with very small quantities, such as a grain or less, which constantly happens, conclusions seem altogether impossible. On this account, and as microscopic researches upon the animal body, combined with the use of water and various reagents, presume an acquaintance with microscopic endosmose, I shall take occasion in this place to describe my own method of proceeding to ascertain the specific gravity of the minutest animal constituents, and connect this with an attempt to expose the laws of endosmose, as they have developed themselves in the course of my inquiries.

1. Every body weighed in water loses, as is well known, so much of its absolute weight (its weight in air) as the water weighs which it displaces. The specific gravity of the body is the quotient obtained when the absolute weight of the body is divided by that of the water which, in its immersion, it displaced.

2. The absolute weight of two bodies being a, α; the specific gravities of the same bodies, a', α'; and the weight of the masses of water which they respectively displace, b, β; then we have for the first body, $a' = \frac{a}{b}$; consequently, $b = \frac{a}{a'}$; and for the second body, $\alpha' = \frac{\alpha}{\beta}$; consequently, $\beta = \frac{\alpha}{\alpha'}$. The first body

lie crowded together, it may appear polyhedral. The cell-germ either fulfils the ends for which it exists, in the state in which it has now been described, or there is a vesicle developed upon and

loses in water, $b = \frac{a}{a'}$; the second body loses in water, $\beta = \frac{\alpha}{\alpha'}$. The weight $a + \alpha$ of the two bodies, when they are mixed and weighed in water, loses as under,—

$$\frac{a}{a'} + \frac{\alpha}{\alpha'} = \frac{a\alpha' + a'\alpha}{a'\alpha'} \; [= x]$$

The specific gravity of the two bodies mingled, is, therefore, x.

$$x = \frac{a + \alpha}{\frac{a\alpha' + a'\alpha}{a'\alpha'}} = \frac{a'\alpha' (a + \alpha)}{a\alpha' + a'\alpha}$$

3. Suppose we have to determine the specific gravity of a minute quantity of a mixture of common salt and water:—

Let the weight of the water be $= 37$; its specific gravity $= 1$. Let the weight of the dissolved salt be $= 3$; its specific gravity $= 2{\cdot}12$; from what precedes, we have the following formula and result:—

$$x = \frac{(1 \times 2{\cdot}12) \times (37 + 3)}{(37 \times 2{\cdot}12) + (1 \times 3)} = \frac{2{\cdot}12 \times 40}{78{\cdot}44 + 3} = \frac{84{\cdot}80}{81{\cdot}44} = 1{\cdot}0413$$

4. Every body thrown into a fluid which remains under its surface, neither sinking to the bottom nor rising to the top, is of like specific gravity with the fluid.

5. Is the fluid sluggishly fluent and mucilaginous, from the admixture of mucilage, albumen, &c., then will very minute bodies, though specifically heavier than it, continue for a long time suspended in it, and only sink through it very slowly, as the blood-globules do in the liquor sanguinis, the albuminous granules in the serous fluids, the gallate of iron (a fine black powder) in the mucilaginous menstruum of ink, &c. &c.

6. In fluids which contain inorganic matters diffused through them, those that are insoluble soon sink to the bottom, remain suspended, or rise to the top, according as their specific gravity is greater, the same as, or less than, that of the fluid. When

around it which is called a *cell*. In the chyle and in the blood it floats at liberty, suspended in the peculiar liquors of these fluids, from which it is engendered; it is, however, commonly met with

they remain suspended, their absolute gravity is equal to the portion of the fluid which they displace. (4)

7. Upon these facts reposes my mode of determining the specific gravity of minute organic elements, as well as of inorganic matters, when they are only to be had in very minute quantity or in the form of fine powder, and when their specific gravity lies (as it all but uniformly does) between that of distilled water and that of a concentrated solution of common salt.

8. It is essential to make use of a fluid in which the organic matters to be weighed specifically are insoluble, and by which they are not altered, either in their chemical composition or in their density.

9. Organic animal matters in the recent state, without any exception, contain water as an integral constituent, and undergo changes in the ratio of the water they contain, by endosmose and exosmose (22), according to the following laws, which are inseparably connected with those of their specific gravities.

10. Organic matters are, in a high degree, hygroscopic, *i. e.* they soon come into equipoise, in point of free watery contents, with surrounding media.

11. This equipoise takes place when bodies and surrounding media have divided the free water between them, in the ratio of their powers of attraction for water severally.

12. Do the watery contents of surrounding media diminish, the organised matter takes up a certain proportion of these. Do the watery contents of media increase, the organic matters lose water to them; and it is in virtue of this principle, that hygrometers, or measurers of the moistness of the atmosphere, are usually constructed.

13. Organic and inorganic watery fluids, when they come into immediate contact, mix with greater or less rapidity according to the laws of affinity, with or without the formation of pre-

also as a principal ingredient of consistent exudations, &c.

§ 41. *Cells.* Cells arise from, or are developed upon, the living cell-germ; upon one of the sur-

cipitates, as the new combinations resulting from the mixture are insoluble or soluble.

14. The mutual attractions of gaseous or watery, of vaporous or fluid substances, are restrained or hindered in a greater or less degree, but never destroyed by the interposition of organic substances between them.

Water included in perfectly close bladders, &c., evaporates through their parietes nearly with the same rapidity as if it were exposed under similar circumstances with the like extent of surface to the open air. The bladder is constantly taking up as much water from within as it is losing by evaporation from without.

15. The direction of the motion through an organised substance, say, an animal membrane, is determined by the position and the predominance of one or other of the effective forces, viz. the chemical attraction or affinity, or the physical weight, pressure, &c.

16. When two precisely similar fluids, or two portions of a precisely similar fluid, such as distilled water, serum, syrup, &c., are separated in a vessel, by an animal membrane, be they placed side by side or lying one over the other, they remain at rest so long as the hydrostatic states are the same in reference to each, when, for instance, they are at the same level, standing side by side, when the pressure on the surface of each is the same, &c.

17. The hydrostatic equality being disturbed in ever so slight a degree, — the one being raised above the level of the other, the pressure on the superficies of the one being greater than on that of the other — then by degrees so much of the fluid will pass through the membrane from the higher column to the lower, or from that on which the pressure is more, to that on which the pressure is less, as is necessary to restore the hydrostatic equipoise.

18. If the substances be different, and a chemical affinity

faces of this, a vesicle arises in the guise of a transparent hemisphere, which, in the beginning, is connected with the cell-germ, as Schleiden has

subsist between them, then the following effects, independently of the physical relations, ensue:

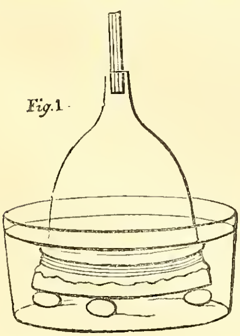
19. When both matters are fluid, they will gradually come to equiponderate in point of their watery contents, through the permeable membrane—the one losing or giving water to the other, in the same proportion as the one has more or has less water than the other; in this way, the degree of concentration of each portion of fluid finally becomes the same.

20. But in consequence of this transference of fluid from the one to the other, the hydrostatic equipoise, it may be presumed, will be apt to be disturbed, and so it is; hydrostatic equipoise only becomes possible when chemical similarity is effected; this accomplished, the physical law comes into operation, hydrostatic equipose is restored, and all subsides into quiet. (16)

21. The same thing follows when the animal membrane separates a menstruum from a substance which is solid but soluble in it; for example, when water and common salt or sugar, are placed in opposition.

Example.—A bladder filled with dry kitchen salt, and well secured, placed in a vessel of water, is penetrated by the fluid with such force that it is finally burst, if it be not all the stronger, or means are not taken to prevent the rupture. This fact led me to the following experiment, instituted with a view to measure the power produced in this way.

Fig. 1



Into the outlet of a glass funnel I luted, by means of sealing-wax, a glass tube thirty-one inches long; I then filled the funnel with dry, crystallised kitchen salt, closed the mouth of the funnel by stretching and tying firmly over it a piece of the dried small intestine of the horse, softened in water immediately before the application. This apparatus I then plunged, the mouth downwards, the glass tube up-well observed, in the same way as the glass is connected with the watch. The formed cell is so much flattened subsequently, that the smaller cell-

wards, the edges of the funnel resting upon three pieces of flint, into a shallow vessel of distilled water. In the course of a few hours the salt became moist, and long before it was all dissolved (therefore with the greatest degree of concentration of the saline solution), in between thirty and forty hours the solution rose in the tube, and flowed over; I then rubbed the upper part of the tube with grease, in order to collect the drops as they escaped, of which, for some considerable time, two fell regularly in the course of a minute; the height of the column of brine in the funnel and tube measured thirty-four Parisian inches. Although in this experiment the end proposed—the determination of the endosmotic force—was not attained, owing to the want of sufficient length in the tube, still the result was striking; for,—The specific gravity of dry crystalline kitchen salt being 2·12, and the substance being soluble in $2\frac{13}{17}$, or 2·7647 parts of water, the specific gravity of the saturated solution must be 1·1632. Now, if a column of mercury, of about thirty English inches, presses with a force equal to fifteen pounds upon every square inch, and the specific gravity of mercury is 13·568, then will a column of pure water, of about thirty-four English feet, hold the column of mercury of thirty inches in equipoise, and a column of water, of thirty-four inches in height, press with a weight of 1·342 lb. upon the square inch, and a column of saturated brine, of the same height with a weight of 1·561 lb.

The diameter of the base of the conical funnel is 32 lines, the basal surface formed by the membrane consequently is 5·266 square inches.

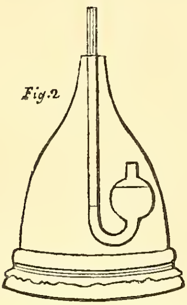
The pressure of a column of saturated solution of salt upon the whole surface of the bladder will therefore amount to 8·22 lbs. Despite this resistance, then, the water attracted by the salt penetrated the membrane from without, in such quantity, that, for a length of time, two drops of the concentrated solution flowed over in the space of every minute.

Second Experiment.—The funnel was filled with a saturated solution of salt, closed in the same way as in the first germ occupies its middle as a nucleus, or there is a nucleolus evolved within a nucleus. The cell, like the simple cell-germ, either remains as such, or it is a mere transition form into other more highly organized products.

experiment, and placed, as before, in distilled water. The solution stood 1 ft. 5 in. 7 lines above the surface of the water at first. The column in the course of the first minute after the immersion sank 22 lines, in consequence of the relaxation of the animal membrane induced by contact with the water; but, in nine minutes, the column had regained its former elevation; and, with the lapse of seventy-eight minutes, the solution began flowing over.

Third Experiment, Fig. 2.

Fig. 2



Over a common barometer tube filled with mercury, a glass funnel was passed, as in the accompanying figure, the space between the neck of the funnel and the tube being made air-tight with sealing-wax, the funnel itself filled with moistened kitchen salt, and its mouth covered with a layer of membrane as before, the apparatus was plunged in a shallow vessel of distilled water, and the upper closed end of the tube broken off so as to allow the mercury to sink and fill the reservoir.

In the course of the first ten hours the mercury rose 101 lines; and, in the course of the second ten hours, 97 lines; twenty-four hours after the commencement of the experiment, the height of the column was 243 lines; and a column of mercury of this length indicates a pressure equal to 10·8 lbs. upon every square inch of surface.

In the experiment just related the following corrections must be made:—

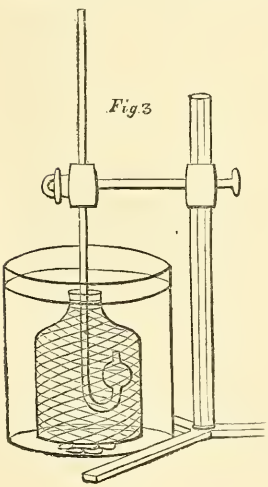
a. By the rise of the mercury in the tube, it sank three lines in the reservoir.

b. On testing the capillary force of the barometer tube, a

§ 42. *Chyle; lymph.* The food—meat and drink — that is taken into the stomach, mingled with the peptic juices — the saliva, the gastric, and intestinal secretions, the bile and pancreatic fluid — and exposed to the nervous influence, heat, and pro-

depression of the mercury equal to four lines was indicated (by so much did it stand under the level of the mercury in the reservoir);

c. The saline solution in the funnel stood twenty lines above the mercury: a height of column that presses with 0·076 of a pound, and holds 1·47 line of mercury in counterpoise; the actual (effective) height of the column of mercury was thus $243+4+3-1{\cdot}47=248{\cdot}53$, and the pressure upon each square inch of membrane therefore 11·09 lbs.; the pressure upon the whole extent of membrane being as many as 58·399 lbs. As the mercury now began to sink, before the whole of the salt was dissolved, there is every reason to believe that the texture of the membrane had suffered so much from stretching, that it became damaged, and unfit to make manifest the maximum of the force developed; the surface of the membrane, too, approached a hemisphere very nearly in figure, by bulging outwards.



The above experiment renders it extremely probable that the chemical power of heterogeneous attraction (endosmose, exosmose) exceeds in amount the pressure of one atmosphere; but this, in consequence of deficiencies in the apparatus, did not appear. The membrane, which is the part liable to undergo change, requires to be supported in some way, and it ought, at the same time, to present the utmost possible extent of surface, in order to manifest the phenomena in their highest intensity, and with their most striking characters. Probably some such apparatus bably some amount of fermentation, forms a thick pultaceous homogeneous mass, the CHYME, the fluid constituents of which are for the most part taken up by the veins and absorbent vessels of the intestinal tract. The absorbed milky fluid—the CHYLE — penetrates by the aid of endosmose and the

as that represented in *fig.* 3 would be found the best. A segment of the small intestine of some large animal, secured by ligature at the one end might be filled with concentrated brine, and the barometer tube inserted and secured at the other. This pouch would then be surrounded with a silk net of due dimensions, and plunged into a vessel of distilled water, as usual.

Fourth Experiment.— The same apparatus as that employed in the last experiment was filled with saturated brine and a quantity of solid salt, and the mouth of the funnel covered with two folds of bladder, and a piece of firm net. After the lapse of thirty-two hours, the mercury began to run over, and a short time afterwards the rest of it was expelled with force, a quantity of the solution following it.

The barometer tube from the under curve measures 374 lines in length ; the depression on account of capillarity is 4 lines.

The pressure of the column of mercury, 378 lines in length, was therefore equivalent to 17lbs. upon the square inch ; the pressure upon the whole surface of the bladder amounted to 89·5lbs. The endosmotic force was here plainly superior to the weight of one atmosphere.

22. When the solvent or attracted fluid in general, penetrates from without, through an organised animal membrane into a closed space (21, Example), the phenomenon is entitled *Endosmose;* when, on the contrary, the fluid presses from an enclosed cavity or space outwards, then is the occurrence spoken of as *Exosmose.*

Examples of Exosmose. A bladder, or piece of intestine, filled quite full of pure water, and well secured, when laid in a saturated solution of salt, or in contact with any dry readily soluble salt, soon becomes lax and partly empty in consequence of Exosmose.

capillary attraction into the minute absorbent vessels (*figs.* 113 and 241), and veins (*fig.* 136) of the intestinal villi, which in their final ramifications are covered by the delicate epithelium of the intestine alone. In the same way are the peripheral

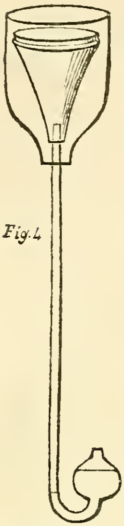


Fig. 4

b. Let the apparatus described in the "third experiment" be so arranged that the funnel shall be affixed, with its base upwards, to the upper end of the barometer tube. Let the interior of the tube and the funnel be now filled with distilled water, and the mouth of the latter be closed with a sheet of bladder, as before; let the funnel be now placed within a second larger vessel, as in *fig.* 4, and this be filled with a saturated solution of salt, until the surface of the bladder is covered; the outer saline fluid will attract the water of the funnel and tube, and this will be followed by a column of mercury from the reservoir, the height of which will serve as an index of the power developed, *within certain limits,* viz. within, or short of, the limits of the atmospheric pressure of the place where, and the moment when, the experiment is made; for the vapour evolved from the water, and the gases with which it may perchance be mingled, becoming free, the column of mercury will not follow beyond a certain point.

23. The endosmotic and the exosmotic effects probably diminish with the diminution in the chemical and physical differences of the fluids separated, in the inverse ratio of the square of the times.

24. The effect, in reference to the quantity of fluid that permeates, stands, under otherwise similar circumstances, in direct relationship to the extent of the free membrane.

25. The quantitative effect is always different according to the nature or quality of the interposed substance; the relative differences connected with this point, however, still require to be ascertained by experiment.

lymphatic vessels of all the external and internal surfaces, and of the interiors of all the solid organs of the body supplied with LYMPH, which is a transparent and yellowish-coloured fluid, and contains effete, and therefore resolved and reabsorbed part-

26. The medium of separation, — the membrane, bladder, intestine, &c. — must have no opening even of microscopic dimensions, otherwise immediate equalisation of the separated fluids ensues without endosmotic phenomena.

27. The more readily the membrane imbibes and transmits water, the better is it adapted to exhibit the phenomena of endosmose; if it be impregnated with oil, fat, resin, and the like, it will shew itself indifferent if brought into contact with watery fluids of dissimilar quality, and no endosmose will take place. The membranous, or other organic septum, therefore, takes an active part in the phenomena of endosmose; it is, in fact, the cause, by its own inherent power, of the interchange of two dissimilar fluids which takes place until uniformity is established.

28. The finer the membranous septum, the more rapid is the process of endosmose, and the sooner is uniformity in the divided fluids obtained. Thick membranes, however, and several folds of membrane, applied one to another, are better adapted to effect and make manifest striking hydrostatic differences, or to overcome obstacles of other kinds, in consequence of the efficient parts of these supporting each other mutually.

29. Double elective affinities still assert their rights when compound matters having mutual attractions, are separated by septa of animal membranes, &c. Few experiments, however, have as yet been made in this direction, although it is probable that in instituting a series, many interesting results for chemical, physiological, and pathological science would be obtained.

30. All the solid, organised animal structures take up a certain quantity of water, more or less, without being dissolved, as is the case with animal matters which possess no organic structure, such as gelatine, coagulated albumen, &c.— an assurance that the hygroscopic and endosmotic property inheres in the matter rather than in the form. On the contrary, under some

icles, fluids taken up from without, and certain combined gases; the lymph also contains upon occasion fluids that have been shed, accidentally or in consequence of disease, in preternatural quantity into the tissues and cavities of the body; and farther,

circumstances they part rapidly with so much of their free water that their decomposition is either delayed for an indefinite period, or entirely prevented (fresh meat laid among dry salt first, and then preserved in brine, anatomical preparations kept in spirits, &c.). Does the endosmose proceed with great rapidity, by reason of the delicacy and smallness of the structures, which are its seats, as is the case with the blood globules, they can even be seen enlarging under the eye, and finally, in many instances, bursting when the distension goes on unequally. It is, upon the same principle, easy to cause a shrinking of these and other minute organic parts, by merely altering the amount of water and more solid matter in the surrounding medium. This circumstance deserves particular attention in microscopic investigations of all minute structures; it also requires to be taken into account in my method of determining the specific gravities of the same class of bodies.

31. In fluids which have the same specific gravity as the substances that are the subject of investigation, these last only change in so far as the contact is followed by chemical changes, and the affinity for water depends more on chemical than on physical relations, such as density, &c.

The condensation of animal matters, by the contact of other matters or fluids having a great capacity for water, affords us a ready means of rendering much more distinct the outline of objects containing a large proportion of water, and which, on this account, and by reason of their slightly different refractive powers, are examined under the microscope with difficulty. Very soft, and even somewhat diffluent structures, become distinct when they are put for a short time into a solution of common salt, of alum, and the like, previously to their being placed under pure water for examination.

To determine the specific gravity of extremely small corpus-secreted fluids, such as bile, &c., elaborated for the purpose of being rejected from the system, when by any accident their excretory ducts become obstructed.

§ 43. The lymph and chyle are in motion from the periphery of the absorbent system through the conglobate glands towards the principal trunk of the entire system, the thoracic duct, by which they are poured, mingled together, into the general torrent of the circulation at the angle of junction between the left subclavian and jugular veins. The parts that are fitted for so important an end now become constituent elements of the blood, and repair the perpetual expenditure of this fluid in the maintenance of the body; the unassimilable parts, on the contrary, are eliminated by the grand depuratory organs—the lungs, the kidneys, the liver, and the skin.

cles, a small light bottle of clear glass, or a delicate test tube must be procured, weighed accurately, and then, from a few drops to a dram or more of a saturated solution of sugar or common salt, in proportion to the size and number of the objects, having been poured into the bottle or tube, it is to be carefully weighed again. The object whose specific gravity is to be ascertained having been previously weighed (when the object is excessively small the weighing may be omitted), is now to be thrown into the solution in the bottle or tube. If its specific gravity is less than that of the solution, it will swim on the surface; distilled water is now to be introduced by means of a pipette, and mixed with the solution by means of a delicate glass rod, until the object of experiment shews a disposition to sink in the fluid, or, being carried some way under the surface, only rises very slowly to the top; the specific gravity of the object of experiment and the fluid may now be assumed to be identical. To determine the amount of the specific gravity, let the glass vessel, with its contents, be now weighed (and when

Chyle.

§ 44. The chemical composition, and the degree of assimilation possessed by the animal fluids at large, are proclaimed, to a certain extent, by the forms of their microscopic precipitates; from these, at all events, conclusions in regard to the extent to which the fluids in which they take place are susceptible of organisation, may be safely drawn. If we follow the chyle from the moment of its appearance, with an eye directed at once to the chemical and microscopic analysis, and mark the various changes which its chief constituents undergo until they appear as cytoblasts, we perceive the advance from binary to quaternary combinations. And again; if we watch the cytoblast from the highest point of

very minute quantities are employed, the rod that was used for mixing may be left in to prevent any waste), the absolute weight of these, the vessel (the rod, in case it is left in), the object (in case it was of ponderable dimensions), and the concentrated solution first introduced deducted, then is the remainder the weight of the water introduced. Suppose this to be found equal to 3, and the weight of the concentrated solution to have been = 2, and its specific gravity = 1·1632, we shall then have the following equation (*vide* 2 and 3), and the specific gravity of the attenuated solution, as well as that of the object, which was the matter of inquiry :—

$$x = \frac{1 \times 1{\cdot}1632 \times (3+2)}{3 \times 1{\cdot}1632 + (1 \times 2)} = \frac{1{\cdot}1632 \times 5}{3{\cdot}4896 + 2} = \frac{5{\cdot}816}{5{\cdot}4896} = 1{\cdot}0594$$

The same end will be attained, and the result come out more accurately, if the fluids are mixed in larger quantity in an areometric tube, and the specific gravity at the end ascertained by means of a delicate areometer, or the hydrostatic balance. That the *temperature* is to be taken into the account, is understood as a matter of course.

its vitality, through the successive stages of its degeneration to its chemical and organic resolution and resorption, we observe a corresponding chemical retrocession from quaternary to binary combinations of elements.

§ 45. The chyle, with reference to its quantity, colour, and chemical composition, and to its organisation and coagulability, differs in the different families and genera of animals, and also according to the kind of food consumed; it also differs essentially in the various parts of the lymphatic system: to such an extent, indeed, does this diversity go, that the chyle may be said to undergo in its course a gradual metamorphosis from an uncoagulable fluid like milk into blood.

§ 46. Near the intestine the chyle consists of water, in which a little albumen, a variety of salts, and other simple and more compound matters, are dissolved, and a multitude of oil-globules are suspended; to the presence of the latter is owing its resemblance to new milk.* The salts are partly

* Numerous observations have persuaded me that in carnivorous animals the opacity and white colour of the chyle are due to the presence of infinitely minute particles, of which neither the size nor the form can be distinctly recognised by the best instruments. That these particles may be of an oily nature, there is some reason to believe; but they appear to me to be quite distinct from the oily globules, for the minute particles in question present an uniform appearance, and constitute the base, or ground, of the chyle, from whatever part of its course the fluid may be obtained; and the oily spherules with the granules are contained in this ground, which may be regarded as quite peculiar to chyle. See the Observations on Chyle, &c., in the Appendix.—*G. G.*

those which are commonly encountered in the animal fluids, partly others accidentally introduced along with the food. Besides salts, indeed, all the substances soluble in water, which are introduced into the stomach, are apt to be—are in fact—absorbed. In the fresh and healthy chyle of the intestinal absorbents, the albumen is in a state of complete solution,—it forms no granular precipitate. Owing to the absence of fibrine, the chyle of the peripheral intestinal absorbents does not coagulate. Examined under the microscope, it is distinguished from fresh milk only by the striking diversities, in point of size, presented by its oil-globules (*fig.* 23).

§ 47. In the afferent or peripheral absorbents of the intestines, the fibrine increases continually in quantity as the mesenteric glands are approached. This increase in the quantity of fibrine appears to take place partly at the expense of the albumen, which loses water, partly of the oil-globules, which become continually fewer and smaller; in the neighbourhood of the mesenteric glands, consequently, we remark a commencing precipitation of albuminous granules.* After the fluid has passed the mesenteric glands, and through the whole of its subsequent course, this precipitate becomes ever

* In the carnivora I have uniformly observed the granular particles, about $\frac{1}{4600}$th of an inch in diameter and in all respects resembling the globules of the Thymus, to be much more abundant in the mesenteric glands than in chyle obtained from any other part of its course whatever. To observe this, it is only necessary to open an animal when the chyliferous vessels are distended, to obtain some chyle from one of the

more and more abundant, and acquires new forms, which will be more particularly mentioned by and by, the oil-globules still diminishing continually both in number and size.

§ 48. In the mesenteric glands, some portion of the dissolved albumen must be changed into fibrine; for the chyle from the vessels advancing from these glands towards the central duct, and from this duct itself, now become considerably more transparent and of a pale reddish yellow colour, coagulates when abstracted from its vessels, and by and by separates into a limpid, serous fluid, and a clot or coagulum,—a consistent gelatinous-looking vitreous mass, which, examined microscopically, is found to include albuminous granules, each surrounded by a delicate film of oil. The granular, and now truly fibrinous coagulum* (*fig.* 15), if kept moist, and suffered to undergo the ordinary chemical decomposition, becomes diffluent, and resolves itself into a kind of serous lymph; the mass, when dried, forms a transparent, brown, horny-looking substance, which is insoluble in water. The serum contains the albumen and the salts in solution, and a proportion of the albuminous granules in suspension.

lacteals of the mesenteric glands, or from a cut into its substance, and compare this chyle with that procured from any of the vessels between the mesenteric glands and the termination of the thoracic duct. See the Observations on the Chyle, and on the Fluid of the Thymus and Lymphatic Glands, in the Appendix.—*G. G.*

* The fibrine of chyle differs considerably from the fibrine of blood, for the former is remarkably less prone to the putrefactive process than the latter.—*G. G.*

§ 49. Mingled with the albuminous granules, the central lacteal vessels, at some short distance from the glands, contain a number of extremely delicate, scarcely-coloured lymph corpuscles, as the organic precipitate of the more highly-vitalised fibrine. These lymph corpuscles are, in fact, cytoblasts,—*blood-globules* in process of formation; and in number, dimensions, consistency, and red colour, they go on increasing continually in their progress towards, and course through, the thoracic duct to its final termination (*fig.* 7).* In the same measure and proportion, the coagulability of the chyle, and the firmness of the coagulum formed, go on increasing. In animals that have been kept long fasting, the fluid in the lacteal vessels does not differ, in point of composition and appearance, from the lymph ordinarily contained in other portions of the absorbent system; there is here an utter absence of the conditions upon which its peculiar characters and appearance depend; it consists but of simple juices pumped up from the alimentary canal, and the resolved particles that have already

* In the horse, Mr. Lane observed that the rosy tint of the chyle from the thoracic duct was due to the presence of the red particles of the blood. (Ancell's Lectures in the "Lancet," 1839–40, v. i. p. 150.) Mr. Siddall and I remarked the same fact. But the blood-corpuscles of the thoracic duct were mostly irregular in form, viz., angular, granulated, indented, or jagged at the edges. There were also many corpuscles of the regular shape, but these were uniformly a little smaller than the common blood discs, as represented in Mr. Gerber's figure. The author's description seems to be entirely drawn from the chyle of the horse.—*G. G.*

performed their part in the structures from which the vessels lead.

§ 50. Tiedemann and Gmelin found the following solid constituents in chyle:—1, albumen; 2, a kind of salivary matter; 3, a species of osmazome; and 4, salts, viz. acetate, carbonate, phosphate, a little sulphate, and a large quantity of muriate of soda; also, a small quantity of potash; and, in the ashes after incineration, carbonate and phosphate of lime. In a dog which had been fed upon starch, sugar was detected by the same physiologists in the chyle; and, upon one occasion, I discovered undecomposed starch in the chyle of a horse, which reacted in the usual way with iodine.

Lymph.

§ 51. The lymph, in different parts of the body, and in different circumstances and conditions of the economy, is of still more various constitution in every respect than the chyle. In general, the lymph is of a yellowish colour in the healthy body; that of the spleen is often reddish and transparent; sometimes it is as pure as water; but, by reason of its dissolved elements, it is always more viscid and sluggish than pure water. Lymph only coagulates when, in addition to its other constituents, it contains living fibrine, which is an element not encountered in a general way in the peripheral parts of the lymphatic system, but only towards its central portions. Albuminous globules present themselves in variable numbers, and sometimes they are wanting entirely; the same is the case in regard to oil-globules,—sometimes they occur, sometimes none can be discovered. The lymph is mixed in the thoracic duct with the chyle, and here the mingled fluid has a pale lake tint; or it is poured directly into the venous system, in various parts, — a fact which can be verified in the horse in almost every part of the body. Foreign unassimilable substances taken up with the lymph as with the chyle, and also effete and waste particles that have already done their office, are seized upon by the different depuratory organs in the course of the circulation, and by them thrown out of the system.*

Blood.†

§ 52. The blood is the product of the chyle and the lymph; it is contained in the heart and blood-vessels; of an intense red colour,‡ sticky to the touch, to the naked eye it appears as a homogeneous fluid; it has a peculiar odour, which, however, differs in different animals; and it has a saltish and what is called faint taste. The specific gravity of the blood varies between 1·045 and 1·061; its temperature in the healthy mammal varies from about 96° to about 99° F., +31° to +32° R.; it generally shews weak alkaline reaction; its quantity, in proportion to the rest of the body, differs

* [For some additional observations on the Chyle, and on the Fluids of the Lymphatic and Thymus Glands, see Appendix.]

† [See Appendix for Mr. Gulliver's Observations on the Blood Corpuscles.]

‡ This, at least, is the case among the vertebrata, — hence called red-blooded animals; invertebrata have generally, but not invariably, colourless blood.

notably, according to the genus, species, age, sex, size, and general condition of the animal examined, and is always determined with difficulty. By Valentin's very ingenious mode of determining the ratio of the blood to the other parts, it would appear to constitute between one-third and one-fourth, or something like three-sevenths of the whole.*

The blood is indispensable to all the vital manifestations; it, therefore, appears with the earliest traces of life in the embryo, and increases in quantity with the evolution and growth of the animal,—previously to birth, at the expense, first, of the vitellary matter of the ovum, and then of the maternal blood; after birth we have seen provision made for its formation out of the fluids, the chyle especially and the lymph, brought to it by particular orders of vessels contrived to this end.

* Valentin's plan of proceeding is as follows:—A small quantity of blood is taken away from the external jugular of an animal of known weight. Whilst the absolute weight of the blood abstracted is determined, a known measure of blood-warm distilled water is slowly injected by the orifice of the vein towards the heart. Some minutes afterwards another portion of blood is withdrawn and carefully weighed. The two quantities of blood are now evaporated in dry air till the residue ceases to lose weight; from the degree of attenuation of the blood effected by the injected water, the previously contained mass of blood can be ascertained by the following formula of Professor E. Volmar: $x = \frac{b \times c}{a - c} + d$.

a Absolute weight of the remainder of the blood first removed.

c Absolute weight of the remainder of the blood diluted with water.

b Weight of the injected water.

d Weight of the blood originally contained in the body.

§ 53. The blood which is propelled from the ventricles of the heart proceeds in two directions,—the one through the lungs, the other through the body at large, in either instance to revert to the heart again, from whence it set out. The vessel, or artery, which proceeds from the heart to supply the pulmonary or lesser circulation, and the vessels, or veins, which lead back the current from all parts of the body to the heart of the adult man and mammal, contain a dark blackish red-coloured blood; the artery, again, of the greater or general circulation, the aorta and its branches, and the veins which return the blood from the lungs, are filled with a bright or crimson-coloured blood.

§ 54. The dark venous blood at its entrance into the heart, mixed as it is with the chyle and the lymph, contains more foreign matter, and a larger proportion of carbon and water than the arterial blood. These various substances are lessened in quantity, or removed under the action of the lungs, the liver, and the kidneys. Venous blood has a stronger smell, and it coagulates more slowly and less firmly than that which is arterial. The blood of the portal vein, which has the distribution of an artery, is often somewhat turbid, and occasionally of a chocolate colour; it coagulates less completely than any other blood, and the clot is extremely diffluent. The blood in the venous spaces of the spleen has many of the characters of that of the portal system, and is moreover somewhat more viscid or consistent.

§ 55. Albumen, fibrine, hematosine, extractive matter, salts, and water, are the principal compound chemical constituents of the blood; in the ashes after incineration, especially of the hematosine or red colouring matter, a little oxide of iron is met with.

§ 56. The organic elements of the blood are discovered by the aid of the microscope. These consist especially of extremely minute globules—the BLOOD-GLOBULES, suspended in the liquor sanguinis as a menstruum. In such quantities do these globules occur, particularly in the carnivora, that they seem to exceed the mass of the fluid in which they swim. Other elements of the blood are separated nuclei of blood-globules and albuminous granules. In the blood of the frog, single very minute entozoa have also been discovered. (*Valentin.*)

§ 57. The blood-globules of the different classes of animals differ in size and form; in the same species of animal, however, they are alike. The blood-globules are specifically heavier than the blood-liquor. Blood-globules begin to make their appearance in the chyle, and it is probable that they are also formed in the blood itself. In the majority, probably in the whole of the vertebrata, they are flat, in the form of a round or elliptical red disc (*figs.* 1 to 6). Those of man and the mammalia look like thick coins, or microscopic muffins or cheeses (*figs.* 4, 5, and 6, 4,). Like all cytoblasts, they inclose in their middle a nucleus of the same general form as the globule, or approximating more to the globular or lenticular shape. This nucleus is generally colourless; in one case firmer than the investing cell, so that it appears with its true figure, in another softer than the envelope, when it is apt to lose fluid by exosmose, and to shrivel; or otherwise, it has a less refractive power than the cell, and then it looks sunk in, so that the entire globule has some resemblance to a garland, or small circular puckered pad.* The blood-globules and their nuclei are elliptical in fishes (*fig.* 1), amphibia (*fig.* 2), and birds (*fig.* 3).

§ 58. In the dry blood-globule of birds (pigeon), the edge of the shrunk nucleus forms an elliptical raised border, in the middle of which, when a section is made of it, a more compact, thicker nucleus projects (*fig.* 6, *B* 3.) In the frog, the nucleus, evenly rounded, projects on either side of the general disc, like a portion of a sphere of smaller diameter placed upon one of larger diameter (*fig.* 6, 2.) In the spider I observed the blood-globule in the shape of a meniscus (*fig.* 6, 1).

§ 59. The size † of the blood-globules varies

* The blood-globules, like all soft microscopic objects, undergo very rapid changes in their forms, apparently in consequence of endosmose and exosmose; they swell up in water, become nearly globular in figure, and then burst. It is impossible, therefore, to use plain water for the purpose of attenuating or isolating the animal fluids and elements, which are the subject of microscopic observation. [R. Wagner particularly recommends the filtered serum of the frog's blood for this purpose. *Vide* Physiology, &c. by Willis, p. 3. Weak solutions of salt or sugar, and urine, however, answer indifferently well; but all addition must be especially avoided when it is intended to measure the corpuscles, or to observe their true forms. Even the serum of the blood of one mammal reacts injuriously on the blood-corpuscles of another. *Vide* "Lond. and Ed. Phil. Mag." for Jan. 1840, p. 25; and Feb. 1840, p. 105.—*G. G.*]

† See Mr. Gulliver's Observations, Sect. I. in the Appendix.

greatly, particularly in different classes of animals, as a comparison of the figures 1, 2, 3, and 4, which are magnified about 450 diameters, will shew at a glance. In the human subject, the blood-globules are from the 300th to the 250th, and the nuclei about the 400th of a Paris line in diameter. In the horse, the blood-globules vary from the 400th to the 240th, and their nuclei are about the 450th of a Paris line in diameter. The lymph corpuscle of the same animal is about the 480th of a Paris line in diameter.

§ 60. The HUSK, or CAPSULE, of the blood-globule, is like the nucleus, transparent, but it includes the hematosine, or colouring principle of the blood. In one case, it appears as a delicate cuticular vesicle, which, besides the nucleus, incloses a viscid fluid; in another, and more generally, it presents itself in the guise of a soft, elastic, and, externally, red-coloured husk, or capsule, which immediately invests the clearer nucleus. The tint of colour exhibited is various — bright, in the globule of arterial blood, dark-red, and somewhat streaky, in that of venous blood. The shell, or capsule, of the blood-globule, is the bearer of the carbon from all parts of the body through the heart into the lungs, and of the oxygen from the lungs through the heart to every part of the body. Venous blood brought into contact with oxygen out of the body, becomes of a bright-red, just as it does within the body; and arterial blood, introduced into a jar of carbonic acid gas, but particularly of carburetted hydrogen gas, acquires the deep tint of venous blood.

§ 61. The NUCLEUS of the blood-globule* is the part in the structure which, in every respect, is the most puzzling; not only is it of different sizes absolutely, but it is so relatively to the shell, or capsule, even among mammals: let the human blood, represented in figure 5, and the blood of the horse, depicted in figure 4, be but compared, and assurance of this fact will be obtained. The nucleus of the blood-globule of the adult mammal resists the action of acetic acid, whilst the envelope becomes perfectly transparent and invisible, perhaps is even completely dissolved under it.† The blood-globules of the fœtus of the mammal, as somewhat larger than those of the adult animal, their nuclei are in the same proportion of greater magnitude, and are but little affected by acetic acid.

§ 62. The number and characters of the blood-globules are found to vary in different diseases. In chlorotic subjects, they are of a very pale colour; and, in reference to the general mass of the blood in anemic states, as after repeated losses of blood, or when there is an excessive demand upon, or use of, the fluid, such as takes place along with extensive suppuration, and when its solid constituents are inadequately renewed, from the want of sufficient supplies of wholesome food, for instance, their quantity is diminished. On the other hand, the globules in relation to the fluid constituents of the blood are increased in quantity after exudations

* [See Observations on the Blood-corpuscles, Sect. IV. in the Appendix.]

† Under the action of iodine, however, it often becomes visible again.

of the liquor sanguinis (plastic exudations, the formation of false membranes), and of the serum (watery exudations and acute dropsies), when the blood is also relatively of a deeper colour than usual.* In plethoric persons, the quantity of blood circulating through the vessels is excessive. If the liquor sanguinis becomes extremely watery, the blood-globules seem to suffer a kind of maceration, and lose a portion of their cruor by solution. Besides all this, the blood undergoes great and signal changes in numerous diseases; in fevers of bad type, in *cholera indica*, &c., it becomes pitchy, and will not coagulate; in *purpura hemorrhagica*, it sets like thin currant jelly, &c.; and, in addition to all this, under certain circumstances, it appears changed to a deadly animal poison, as in anthracion, or malignant pustule, in *rabies*, hydrophobia, &c.

§ 63. In the minuter currents, the blood-globules have the effect of producing an optical interruption to the continuity of the stream; by which the circulation of the blood becomes visible in the more transparent parts of the bodies of living animals, viz., in the extremities of young spiders, in the fins of fishes, in the gills of the larvæ of the newt and frog, in the tail of the water-

* [Some of these statements are to be received with caution. In diarrhœa and cholera the blood does certainly become pitchy, both in consistence and colour; but in acute dropsies nothing of the kind occurs as a general rule: if, in these cases, there be a certain loss of serum into the general cellular tissue of the body, there is accumulation of this fluid to a far greater extent within the blood-vessels in consequence of the suspension of the functions of the kidney, skin, and, indeed of every emunctory of water from the system.]

newt (*fig.* 6, A), in the web of the frog's foot, in the mesentery of the smaller mammalia, &c.* In the smallest blood-vessels of all, the blood-corpuscles follow each other in single files; and the diameter of the final conduit, therefore, stands in a determinate ratio through the entire series of the animal kingdom to that of the globule which has to be transmitted.†

§ 64. During the unimpeded coagulation of the blood, the blood-corpuscles apply themselves flat one to another, so that they form elongated cylinders (*fig.* 8).‡

§ 65. Nearly allied, and of like origin, to the lymph and blood-corpuscle, are the exudation-corpuscle, the true pus-corpuscle, and the corpuscle of ulcerated surfaces, — the ichor corpuscle. Exudation-corpuscles always appear in the vital liquor sanguinis, when this comes into contact with the

* This most interesting and instructive spectacle of the circulation is best enjoyed by making use of low powers, and having a wide field. There is nothing in nature more beautiful than the spectacle that then presents itself.

† If this be true, as it probably is, how remarkably the intermediate blood-vessels must differ in size! It would be interesting to examine them in the Proteus; and still more to compare the size of the capillaries of the Napu musk-deer (*Moschus javanicus*, Pallas) with those of the mammalia having comparatively large blood discs. The subject, too, gives additional interest to observations on the size of the blood-corpuscles in different animals. See my Appendix on the Blood Corpuscles. — *G. G.*

‡ To procure columns of blood of this kind for microscopical examination, let a plate of glass be wetted with blood as it is flowing from the vessel; then incline the plane so as to let all drops fall off, and to have the surface merely moistened.

living tissues of the body out of the blood-vessels. The globules of unhealthy suppurating surfaces are blood-globules which have escaped from vessels destroyed by the ulcerative process, and been altered by the action of the ichor or watery fluid amidst which they are contained.* Pus-globules arise when exudation-globules are only mediately in contact with the living tissues. Of these cytoblasts we shall have more to say by and by.

§ 66. The lymph, or fluid (blood-lymph, liquor sanguinis, s. plasma), in which the blood-globules swim, and the perpetual expenditure of which is supplied by the lymph and the chyle, is a clear, yellowish-coloured fluid, from which, when it is left at rest, the fibrine separates by coagulation, after a variable interval, the limits of which may be stated at from one to twenty minutes. The separation is more quickly accomplished in carnivorous and strong animals than in frugivorous and weakly subjects. With the included blood-globules the fibrine, after its coagulation, forms the CRASSAMENTUM, or CLOT, which is by so much the more solid as the means of its previous solution — the SERUM — escapes completely from it, which happens particularly in the case of vigorous men, and animals of the male sex, and, under all circumstances, in regard to arterial blood. The superior surface of the crassamentum consists of a thin layer of pure fibrine with a few oil-globules disseminated through it.

§ 67. When coagulation takes place slowly, the specifically heavier blood-globules sink in the liquor

* See note at page 28, and at page 41.—*G. G.*

sanguinis, so that a relatively thick layer of pure fibrine covers the surface of the clot, and constitutes the *sizy*, *buffy*, or *inflammatory coat*, or *crust*.*

If freshly-let blood be beaten with a rod, or a mass of crassamentum be washed, the fibrine is procured by itself in the form of white fibrous bundles, or of a tough fibrous mass (*fig.* 15, A). Fibrine that has coagulated in the form of a hyaline mass, as it does when it forms the buffy coat, by and by becomes granular (*fig.* 15, B). If it sets in immediate contact with the living tissues of the body, it is, in due season, organised; — exudation-corpuscles (*fig.* 205, 1, 2, 3) are formed, which, arranged one by another upon the living surfaces, constitute exudation membranes (*fig.* 206), or, more remotely from these, undergo transformation into productive pus-globules (*fig.* 9, *b*); and these, with serum and albuminous granules, form true laudable or healthy pus.

ORIGIN, EVOLUTION, AND ULTIMATE STRUCTURE OF THE LIVING CONSTITUENT ELEMENTS OF ANIMAL BODIES, AND OF THE ANIMAL TISSUES.

§ 68. A course of microscopical researches into the nature of the different morbid secretions and exudations, particularly of the transuded products of inflammatory action upon the surfaces of internal

* Upon the artificial formation of this layer, see the explanations of the figures from 11 to 14.

Some excellent observations on the formation of the buffy coat will be found in Dr. Davy's "Physiological and Anatomical Researches," vol. ii. p. 46.— *G. G.*

cavities, led me, among other particulars, to investigate the subject of apparently accidental secondary organisations. I followed the secondary organising process in the products of suppurating wounds; the primary formative processes I traced in the impregnated ovum. I shall find no better or fitter place to make known the more important results of these inquiries than the present; and these I shall, accordingly, ingraft in the immediately following paragraphs, which treat of the genetic relations and developement of the different tissues. But let us, as a means of securing clearer comprehension of the matters to be stated, begin with a consideration

Of the Motions and Changes of Place of the Fluids.

§ 69. *In vessels.* In the normally constituted healthy living body, the blood is found in constant motion in every part of the vascular system, so that each individual blood-globule may, by possibility, perambulate every point of the greater and lesser circulation many times; the chyle and the lymph, on the contrary, perform but the single journey from the point of their absorption through the intervening lymphatic vessels and their appertaining glands, to that at which they are poured into the blood. The same thing obtains in regard to the motions of the various secreted fluids; they are conveyed directly, and, once for all, from the point of their elaboration, through the nearest secretory canals and excretory ducts to that at which they are to be made use of specifically, or to be discharged from the system.

Gravitation of the Fluids.

§ 70. All the fluids of the body gravitate by their weight towards the most depending parts of the close cavities, and even of the tissues generally, where they would accumulate, were they not maintained in parts that lie higher by some superior force, or were they not continually brought back to these, as the blood is by the force of the heart, the chyle and the lymph by the contraction of the vessels, adhesion to the parietes of these, and the interchange of compression and relaxation through the action of neighbouring muscles, particularly those belonging to the respiratory system.* In the healthy living body there is little evidence of mere mechanical gravitation of fluids, even to the most depending parts: but in the dead body the case is different; there the fluids immediately begin to gravitate to those parts that are on the lowest level, where they accumulate and are met with in greatest quantity.†

* [And unquestionably, also, and probably of more avail than all the *vis a tergo* generated by the perpetual afflux of fluids, in virtue of the heterogeneous affinity developed at the extremities of the lymphatic system.]

† [A human dead body, in a leaden coffin closely soldered, does not undergo decomposition to any extent, for, it may be, twenty, thirty, fifty, or more years; but the whole of the fluids fall through it: a dryish, mummified mass is found lying in a depth of an inch or more of a reddish serous fluid.]

Hydrostatic or Passive Congestion.

§ 71. Even during life a depending part of the body receives more blood than when it is placed horizontally, or raised above the level of the source whence it is supplied. The legs, as the most depending parts of the body, are, therefore, subject, in the greatest degree, to this passive or hydrostatic congestion; and we have constant evidences of its occurrence in the frequently overloaded and varicose veins of the lower extremities, which disappear when the legs are laid horizontally, or raised to a very small angle with the rest of the body. Stooping the head is also familiarly and universally known to be followed by a preternatural accumulation of blood in that part, which is in a great measure the effect of simple gravitation.*

* [Despite this simple and familiar fact, however, some of our physiologists have denied that there could by possibility be more blood contained in, or circulating through, the brain at one time than another. The brain, it has been said, is *incompressible*, and, filling exactly the hollow sphere of the skull, cannot have more blood circulating through it at one time than another. But the brain is far from being incompressible; it is, on the contrary, highly elastic, and, therefore, compressible. Were it as incompressible as water, however, it may still *be subjected to pressure.* If we adapt a forcing-pump to a hollow sphere full of water, and endeavour to throw more fluid into it, though we find this impossible, the contents of the sphere are obviously in a very different condition from what they were before we began to force. So it is with the cranium: the shut sphere of the skull is still in communication with the powerful forcing-pump,

Active Congestion.

§ 72. Transient dilatations of the capillary vessels (probably induced by diminished contractile powers, the effect of a kind of temporary and limited paralysis), also occasion local increment in the quantity of blood; a congestion of this kind is apparent, and passes rapidly off, in the blush of modesty or shame; we have instances of more permanent morbid congestion, accompanied with a stasis of the blood, and the known phenomena of reaction, in inflammations.

NORMAL ESCAPE OF THE FLUIDS FROM THE VESSELS.

General Endosmotic Transudation.

§ 73. Nutrition, secretion in glands, and the like, without free or open-mouthed terminations of

the heart; and if the injecting power and the quantity of blood sent forward exceed the capacity of transmission in the same time, there will certainly be pressure exercised on the brain. The anatomical arrangements in connexion with the circulation through the cranium; the provisions made to prevent the arteries from expanding in their calibre, in other words, from transmitting blood in excess; and, on the contrary, the beautiful contrivance by which the sinuses are defended from suffering any diminution in their areas, — the arteries reaching their destination through *tortuous, unyielding, bony canals;* the sinuses *braced out in three directions,* (as few as were adequate, and not more than were necessary to keep them constantly pervious), all give us assurance that, under certain circumstances more blood might circulate through the brain at one time than another.]

vessels, presume an exudation and transudation of the constituents of the blood to take place through the parietes of the vessels. Endosmotic transference of heterogeneous fluids, separated from each other by solid tissues, certainly occurs through every part of the body during life as well as after death ; and this in consequence of one of the universal chemical or physical laws, which has been designated that of *heterogeneous attraction.* That such a process is constantly going on, is made obvious among other phenomena by the communication of colour from one part to another : all the parts in the neighbourhood of the gall-bladder are dyed yellow or green ; and other parts, lying in contact with such organs as the liver, the spleen, &c., which are extremely rich in blood, are regularly stained of a reddish or brownish hue ; this occurs to a greater extent in the dead body, indeed, than in the living, from the serum after death dissolving some portion of the colouring matter of the blood ; but, still, it undoubtedly takes place, to a certain amount, in the living body also.*

* "A popular objection to this view," says Mr. Mayo, in his Outlines, "is founded upon the fact, that on opening the body of an animal immediately after death the parts adjoining the gall-bladder are not tinged with bile. But it is easier to imagine that the bile is in this case washed away by the circulating blood, or carried off by the lymphatics as fast as it exudes, than to suppose a new principle in the living body competent to suspend the common laws of imbibition by porous substances."— *G. G.*

MORBID ESCAPE OF THE FLUIDS, PARTICULARLY OF THE BLOOD FROM THE VESSELS.

Extravasation.

§ 74. When, in consequence of a fall or a blow, a part of the body is bruised, or injured in its intimate texture, its vessels ruptured, &c., but without breach of the surface, we have *extravasations* formed, — effusions of blood, of milk, &c. into the tissue of the organ injured.

*Exudation.**

§ 75. On all the external and internal surfaces of the body there is a constant escape, in consequence of transudation, of one or more of the constituents of the blood, or of some peculiar fluid, with which these surfaces are bathed, or by which the cavities they form are filled in a greater or less degree. The fluids transuded in this way are liable to be greatly increased in quantity under particular circumstances. The cutaneous perspiration, the watery fluids poured into the serous and mucous cavities, the gastric and intestinal fluids, &c., are products of normal and necessary functions of the kind alluded to. These exudations may, also, become morbidly altered, both in quantity and quality : poured out in excess into the shut sacs of the body, such as the

* The term *exhalation* is only applicable under circumstances where the atmosphere or some gaseous fluid is present, as is the case, for example, with the skin and the mucous membrane of the lungs. Exhalation, therefore, can never occur in the serous sacs, or other close cavities of the body.

ventricles of the brains, the pleuræ, the pericardium, the peritoneum, and the general subcutaneous and inter-organic cellular tissue, they form dropsies; poured out upon the surfaces of open passages, such as of the nose, the lungs, the bowels, &c., they form profluviæ of different species,—coryza, pulmonary catarrh, diarrhœa, cholera, &c.

Morbid Exudation in consequence of Inflammation.

§ 76. In the serous and synovial sacs, in the cellular tissue, &c., it is common to observe inflammation terminating in effusions of different kinds; in one case, of the *watery or serous element* of the blood; in another, of simple *plastic matter*, when the liquor sanguinis exudes without the blood-globules; and in a third, of *sanguinolent matter*, when the liquor sanguinis exudes, tinged with the colouring matter of the blood, or actually mingled with a smaller or larger proportion of blood-globules.* This last form of exudation forms the transition to hemorrhage.

Morbid Exudation of Blood (Hemorrhage).

§ 77. When the blood escapes from open vessels, externally or internally, it is spoken of as external or internal hemorrhage.

* Blood-corpuscles are repeatedly found, quite unaltered in appearance, on the mucous surfaces, when no solution of continuity whatever can be detected in any of the vessels. Mr. Siddall and I saw a remarkable instance of this in the horse. The lining membrane of the trachea was throughout coated with a deep red viscid matter, the colour of which was found to be owing to numberless blood-discs. These, however, soon became

§ 78. In the fluid of *serous exudations* it is usual to find the albuminous granules of albuminous fluids, and when the greater part of the serum is again removed by absorption, should this occur, the crystals of different salts. When the quantity of exuded serum is considerable, or the effusion continues long, it is apt to penetrate other contiguous and more dependent parts, and so to produce a partial or more general dropsy.*

§ 79. After plastic exudations, or mingled serous and plastic exudations, a yellowish, turbid fluid is found in the affected cavity, having fine flocculi, of a pale yellow colour, floating about in it, or precipitated upon, and perchance adhering to, the bounding parietes in every part. The serous membranes, cleared of these deposits, are found unaltered, and

granulated, and very irregular in form, and then scarcely or not at all visible, from solution of their colouring matter. The escape of the blood-corpuscles from the capillaries, under certain circumstances of disease, will not appear so surprising, if we consider the remarkable softness and elasticity of the corpuscles, and the facility with which they change their form, becoming bent, compressed, or elongated, so as to adapt themselves for the passage of any unusually narrow channel. After passing the obstruction, they recover their usual shape with singular rapidity. Some of these temporary alterations in the blood-discs may often be very well observed when they are mixed under the microscope with currents of grosser particles, as of pus-globules. See the Observations on the Blood-corpuscles of Mammalia, Sect. III. in the Appendix.—*G. G.*

* [Even partial dropsy must be regarded as an extremely rare occurrence from such a cause: it is very doubtful whether general dropsy was ever seen as its consequence. The cause which is at work producing the local accumulation of fluid is then inducing a general accumulation.]

the injected vessels that appear are not included within, but lie under them. If, instead of the turbid serous fluid mixed with small flocculi now mentioned, larger continuous masses of coagulable lymph are encountered amidst the effused serum, the exudation, it may be concluded, has taken place very rapidly.

§ 80. When the exudation of plastic matter goes on for any length of time, and the quantity of effused liquor sanguinis is considerable, the cavities into which it is shed may be filled with it; or their parietes, and the organs they include, — the heart, lungs, liver, intestines, &c., may become covered with thick layers of coagulated fibrine. This, at first, is of a pale yellow hue, and somewhat translucent, and has the consistency of imperfectly coagulated albumen. If death occur at this stage, the hyaline substance quickly becomes granular, and, in consequence of chemical decomposition, is dissolved in the serum. If no fatal event ensue, the characters of the exudation are otherwise altered.

§ 81. In an animal* debilitated to a great degree, the exuded fibrine is discoloured, is greyish or greenish instead of white or pale yellow, as if it were going to change into pus, which, however, it never is;† under the microscope the matter has

* When no particular animal is mentioned, the horse is to be understood as the subject of observation. All that is stated in this and some of the following paragraphs, applies, however, with trifling modifications, to man and the other mammalia.

† I have never seen *suppuration*—the formation of true pus—take place in the shut sacs of the serous and synovial membranes where there was no external wound; I believe that it

all the characters of corrupting fibrine, a sign of approaching death.*

never happens. When pus is found in any of these sacs, careful inquiry always shews that it has been produced in tissues which were covered by the serous membranes, and that it has only made its way into the cavities after permeating the membranes. Empyema, therefore, is never a product of the pleura, never an immediate effect of pleuritis,—a title, by the way, which is radically objectionable, inasmuch as the serous membrane itself never participates in the inflammation of the highly vascular cellular tissue which it covers, and is only affected or altered by the morbid processes there going on, in so far as it depends for its nutrition and continuance on the capillary rete, which lies on the outside of it, and which is, in fact, the tissue that is obnoxious to inflammation. [In 1722 Dr. Simson, of St. Andrews, regarded pus as a secretion, and Dr. Morgan, of Philadelphia, and Brugmann, of Leyden, promulgated this doctrine throughout Europe. Mr. Hewson especially noticed ("Exp. Inq." Part. 2, p. 117,) that pus was often found in the serous cavities, without any erosion or the least mark of ulceration; and the Hunters insisted on the production of pus, both by the mucous and serous membranes, independently of any breach of surface whatever. Indeed, this view of the matter is now, and has long been, generally entertained.—*G. G.*]

* This is a very interesting fact, and if confirmed would serve to explain the circumstances we observe after opening extensive abscesses, performing the operation of paracenthesis of the chest, &c. Perforation of the thorax is an operation simple enough in itself. So far as the division of parts is concerned, there is no more risk in reaching the bag of the pleura than in opening a vein to let blood; the same may generally be said in regard to discharging an extensive abscess. But the consequences of either operation are often disastrous; and this probably from a change induced in the effused matters, that causes them to be felt as foreign by the living parts with which they are in contact. Excitement of a new kind is set up in the seat of the local mischief, and then comes secondary fever with the hectic type, and all the train of disastrous symp-

§ 82. If the inflammation ends with the exudation, and the disease, and the loss of vital fluids consequent upon it, have not exhausted the strength of the animal, the exuded and coagulated fibrine, under otherwise favourable circumstances, is by so much the more quickly and completely organised as the creature is vigorous.* The exuded serum is gradually removed by absorption, whilst the particles and masses of fibrine which float loose in it are dissolved. The particles and masses of fibrine which are attached, on the other hand, become of a bright yellow colour, and, examined under the microscope, are found to consist of adhering or connected exudation-globules, which are formed in

toms that so frequently render the discharge of large abscesses, and especially the operation of paracenthesis of the chest fatal,—the untoward tendency being doubtless increased in the latter instance by the importance of the organ interested. *Vide* the note at p. 28.—*G. G.*

* It would appear, however, from some valuable observations by Mr. Dalrymple, that the organisable material of the blood, when effused without direct rupture of the vessels, is more rapidly organised in those conditions of the system denominated cachectic than in the more vigorous and robust. In the latter, he is of opinion that inflammations more quickly pass into the suppurative or ulcerative stages, while in the former the effusions of fibrine become more rapidly organised, and are apt to remain as persistent structures. Many of his conclusions are deduced from cases of ophthalmic diseases, which are peculiarly favourable for observation, and in which the rapid organisation of exuded fibrine in cachectic subjects with syphilitic iritis is remarkable as compared with idiopathic or traumatic iritis in more vigorous constitutions. Mr. Dalrymple's injections seem generally to support his views as to the very rapid organisation of fibrine under the circumstances mentioned. *Vide* "Med. Chir. Trans." vol. xxiii.—*G. G.*

from twenty-four to thirty hours after the occurrence of the exudation,* when the masses are of a ruddy yellow,† and have acquired such consistency, that they can be peeled off in cohering shreds from the membranes to which they are attached.

§ 83. Exudation-corpuscles (*fig.* 205) are, in every respect, the same as the lymph-corpuscles.‡ They generally form many superimposed layers, being laid flat one over another, and so constituting

* Nuclei, with or without envelopes, may be found in fibrine as soon as it has set, independently of inflammation. *Vide* note p. 31. — *G. G.*

† Like that of the chyle in the thoracic duct, this is the almost uniform colour of the fully evolved cytoblast. In those animals whose mature chyle is of a paler colour, the exudation-corpuscles are paler also — an assurance of their identity in all the parts of the body of the animal in which they are examined.

‡ In mammiferous animals, it has always appeared to me that the lymph-globules differ in size, structure, and chemical characters from exudation-globules. The latter are larger, more irregular in size and shape, more spongy or loose in texture than the former. Besides, the exudation-corpuscles generally exhibit two or three nuclei when treated with acetic acid, whereas the lymph-globules are only rendered slightly smaller by this reagent; and the acid either dissolves or makes remarkably fainter the comparatively thick shell of the exudation-corpuscle, while the lymph-globule becomes more distinct when subjected to the action of the acid. It is true that an occasional appearance of a nucleus is presented by the lymph-globules when thus treated; but this is, for the most part, a single globular particle nearly as large as the entire lymph-globule, as if produced simply by the most superficial part of the globule being very feebly affected by the acid. The lymph-globules, in fine, in progress of developement, may soon become more or less coated with fibrine; but, if examined at an early period, they will be found to resemble in chemical characters the nuclei (nucleoli of Valentin) of primary cells, — a fact which appears to me to be of consider-

membranes which bear the strongest possible resemblance to those composed of the tessellated epithelium (*fig*. 103, *b*), when the connecting medium has disappeared, by which the edges of the primarily round corpuscles come into contact, and are thus forced into the shape of polygons.

§ 84. Some hours later a greater degree of cohesion, and stronger indications of a fibrous structure, are observed in the exuded mass; and, under the microscope, an ever-increasing linear arrangement of the component globules, which appear more intimately united at two opposite points in one line, by means of the connecting cytoblastema, than any

able interest. To make this examination satisfactorily, the globules should be examined in the fluid of the lymphatic glands, or in that of the thymus body. I have kept portions of the latter for weeks in acetic acid without producing any other change in the globules than a slight diminution of size, and an increased distinctness and smoothness of their outline, probably in consequence of the removal of a very delicate commencing fibrinous concretion from their surface. In structure, magnitude, and chemical properties, the globules of the lymphatic glands and of the thymus are identical. I subjoin, from my notes, measurements, expressed in fractions of an English inch, of the exudation-globules and of the lymph-globules of the horse. The former were obtained from fibrine effused upon the inflamed pleura, the latter from a lymphatic gland of the thigh:—

Exudation-Globules.		Lymph-Globules.	
1-3200, 1-2900, 1-2666	Common sizes.	1-5333, 1-4800	Common sizes.
1-4572, 1-2286	Extremes.	1-6400, 1-3200	Extremes.
1-2962	Average.	1-4626	Average.—*G. G.*

where else (*fig.* 102, *c*, *d*) is apparent: the rest of their edges is comparatively free. If the cytoblasts were globular at first, they now acquire more of a spindle shape; the flat ones continue more flattened after their margin has become fusiform, and in a linear direction they represent, in connexion, varicose fasciculi, in the enlargements of which the nucleus of the exudation-globule continues visible, and either subdivides into several granules, or has a new nucleolus evolved within it. Betwixt the cellular fibres which have now been formed, there still remains an interposed hyaline substance, so that the masses may be separated mechanically, or torn in any direction, almost with like facility. Under a low magnifying power the cellulo-fibrous mass appears as it is represented in *fig.* 17.

§ 85. At the parts where the villi and festoons connected with the free surface of the exudation exhibit a greater degree of cohesion, we also observe the commencement of the transition of the cellular fibrils into round filaments. This transition appears to require either a longer time to attain completeness than the formation of the cellular fibres out of the recent exudation, or the organisation here remains stationary under peculiar and still unknown circumstances, just as it seems to do with reference to the same structures even in the primary tissues of adult animals, — for example, in the sheaths of the soft nerves and more delicate vessels (*figs.* 102, *c*; 103, *d*; and 163, *b*, *e*). With the progress of the formation of round filaments, the intercellular fibrils get longer (*figs.* 218 and 219), whilst the fusiform nuclei get smaller, and at length entirely disappear. Occasionally one cell is observed to be connected laterally with another lying near it, and then three intercellular fibres proceed from it (*fig*. 219, *c*).

§ 86. Even before the formation of round filaments, duly ordered blood-vessels make their appearance, and form a capillary net-work, as they do in the intestinal villi. First, transparent arborescent streaks are seen, which push out their increasing ramuscles on all sides, to encounter one another, and form a series of reticulated inosculations. But before the vascular rete appears, pale-coloured cytoblasts have been produced, which, after the completion of the rete, pass over into the nearest primary capillary veins, whilst they are pushed onwards by the blood of the nearest primary arteries ; and in this way is the circulation established through these secondary formations. The vascular rete is more intricate in the larger villi and festoons (*fig*. 20), and the distribution here resembles, in every thing, that of the intestinal villi (*fig*. 136). Here may be distinguished the terminal divisions of the arteries (*fig*. 21, *a*), the terminal divisions of the veins (*b*), and the further subdivisions of these vessels into capillary arteries (*c*), capillary veins (*d*), and intermediate or transition vessels (*e*, *e*). In the smaller villi the blood-vessels comport themselves like those of the gills and toes of the larva of the newt, and those that accompany the isolated single nervous fibrils of the skin ; that is to say, they run simply along the edges of the parts.*

* Mr. Liston has given an extremely clear description of the arrangement of the intermediate vessels of granulations, as they appear in the cysts of abscesses and on open sores. In abscesses the capillaries project into the new and adventitious lining mem-

§ 87. Long after the occurrence of exudative inflammation, and when all traces of diseased action have subsided, the serous membranes implicated are found thicker and less transparent than proper; the organs which they cover are also found adhering to one another, and to the parietes of the cavities in which they are contained; longer and shorter white lappets hanging from the surface of the viscera and containing walls, and strings, broader bands and continuous sheets of false membrane, passing in various directions from the one to the other, and connecting the viscera together, and with the sides of their containing cavities. These various accidental structures are all of the same essential nature: they have the general appearance of serous membranes, and consist of rounded filaments firmly united by a common vitreous substance (vide *fig.* 18, which is a representation of a mass of connected cylindrical fibrils seen under a low magnifying power). Sometimes the round filaments are but loosely bound together, and entirely correspond in structure with primary cellu-

brane, often in straight parallel lines, though the arrangement of the vessels in the granulations on the free surface is distinctly looped and tortuous, with communications between the loops, this vascular arrangement being much like that of healthy secreting surfaces. In a portion of injected ulcer the vessels of the granulations were found to be similarly arranged, but enormously and irregularly dilated or varicose,—a fact which suggests an important therapeutical indication. Mr. Liston has also demonstrated the existence and arrangement of the vessels in the cartilage of diseased articular surfaces, so that the possibility of this tissue being nourished, absorbed, or repaired by its own vessels, can no longer be doubted. "Medico-Chirurgical Transactions," vol. xxiii. p. 85.—*G. G.*

lar substance and tendon (vide *fig.* 19, where *a* is a representation of the cellular filament, *b* of the filament of tendon, the fibres being parted or teased out in either case).

§ 88. The same phenomena are observed in inflammations with plastic exudations of the synovial as of the serous membranes; in the capsular ligaments of joints, therefore, in the bursæ mucosæ, and in the sheaths of tendons, precisely the same products are encountered.

§ 89. The same formative processes are also observed in the chorion of the impregnated ovum; and, indeed, under all circumstances where the exuded living liquor sanguinis or cytoblastema, left at rest in closed cavities, is in a condition to become completely organised; as, for example, when it is deposited on the parietes of abscesses containing laudable pus, &c.; and these secondary products of organisation, it is to be observed, are never to be regarded as accidental, — they are perfectly indispensable to the repair of any injury that has been suffered, to the maintenance of the individual who has been its subject.*

* When, for instance, inflammation of the shut sacs of the body (the serous and synovial membranes) has exceeded the limits at which resolution is possible, or when it has destroyed all capacity in the part to perform its function, then is this termination, by an exudation of coagulable lymph, the most favourable that can occur; nay, it is the only one that renders a recovery (which, however, may only be relative) possible: an organisable deposit has become necessary to the restoration of the part, and such a deposit is coagulable lymph; without its presence the serous effusion of the inflammation would become a stagnant, dropsical effusion; but the newly-formed villi of plastic

FORMATION OF PUS, AND REPRODUCTIVE ORGANISATION IN SUPPURATING WOUNDS OR SORES.

§ 90. Simple incised wounds, made with a clean sharp instrument, heal, by what is called the first intention, in the course of a few days — almost of a few hours, when the wounded surfaces can be brought into apposition without dragging, and the reparative process is suffered to go on undisturbed. In this case, the fibrine of the extravasated blood fills up all the smaller accidental hollows in the depth of the wound; cytoblasts are then produced, these are transformed to cells which acquire a final organisation in consonance with that of the parts injured, and the superficies of the wound is repaired, — the adjacent edges are united by means of a secondarily produced firm tissue, universally known by the name of *cicatrix*.

§ 91. Wounds with a loss of substance, gaping sabre-wounds, gunshot and other wounds, where a certain degree of bruising attends the solution of continuity,—wounds, too, that have been filled with foreign substances, dirt, &c., which must be got rid of before they will *cicatrize*, all heal by *suppuration*. The process in these cases is as follows: —

§ 92. After having bled to a greater or less extent, the wound becomes stiff, and painful, and

lymph, projecting into the affected cavity, increase the extent of absorbing surface, become vicarious of the functions of the now incompetent membrane, and remove immediately the serum which has become free in consequence of the coagulation of the exudation.

dry; an exudation of the liquor sanguinis is then established from the entire extent of surface, and this goes on incessantly till the injury is repaired. The fibrine, as it coagulates on the raw surface, forms *exudation-globules,* or cytoblasts, many of which cohere in layers, and compose the *false membrane* that finally invests the entire superficies of the sore. The layers of globules in most immediate contact with the living tissues become *cells,* which then undergo further transformation, in accordance with the nature of the structure to be reproduced; those layers of globules, again, which are most remote from the living parts become *pus-globules,* and these, mingled with a small quantity of serum, compose true or laudable pus, which, on the one hand, indues and protects the focus of organisation, separating the *granulating surface,* as the surface of a wound in process of repair by suppuration is called, from external agencies; and, on the other, forms the soft, mild medium in which reproduction goes on from the more remote parts towards the centre, and by which foreign substances are detached and removed from the sore.

Pus.

§ 93. The exudation-globules, which lie beyond the vivifying influence of the surface of the wound, and exposed to the action of external agencies, cannot be expected long to retain their vitality; these globules, therefore, forsaken, as it were, by the organising principle, begin to degenerate in their organisation, and to suffer changes in their chemical constitution, whilst those that continue in immediate contact with the living structures of the body advance in their organisation: those globules that are cast loose then die — *mors vitæ origo.*

§ 94. On the exudation-globules that are free, a number of delicate lines, radiating from a centre, are first perceived, which divide their peripheries into from six to eight (seldom more) segments; these lines become more and more distinct, and the capsule appears as if it were torn or cleft, but without separation of parts; in many globules, too, the nucleus now appears to incline to fall into from two to four pieces (*fig.* 9, *a*; *fig.* 10, *i*, *k*); the originally reddish yellow colour of the globules fades,* the segments of the envelope and the divisions of the nucleus, which had been linear and sharp in appearance, become rounded off till they appear like aggregated granules, whilst the pus, now completely formed, acquires a greenish yellow hue.

True pus-globules, formed in both these ways, may still be found, here and there, hanging together like the cells of the tessellated epithelium; they are specifically heavier than serum, appear under the microscope somewhat larger than lymph, exudation, and blood-globules (they generally measure from the $\frac{1}{300}$th to the $\frac{1}{700}$th of a Paris line in dia-

* The colour of microscopic objects fades in the ratio of the magnifying power, in consequence of the apparent subdivision of the matter in which it inheres, and its diffusion over a larger extent of surface; but on the other hand, colours appear under the microscope which had escaped the naked eye entirely; thus fine threads and single fibres of cotton, highly magnified, appear entirely blue; colours are usually perceived as they present themselves to the naked eye.

meter), are of a yellowish colour, and usually mingled with oil-globules and albuminous granules; they are often seen besprinkled with albuminous granules, which are then by many mistaken for integral parts of the globules, their larger proper granular subdivisions,* which together give the pus-globules the appearance of lenticular or muffin-shaped cushions tucked in at different distances by lines radiating from a common centre, being overlooked (vide *fig.* 10, *i*, the pus-globule from the flat surface, *h* from its edge: the variety here represented is that with quadrifid nuclei). By and by the granules separate to a greater extent (*fig.* 9, *b*), so that the corpuscles resolve themselves into their elements; for old pus consists, in great part, of these more or less completely isolated granules.†

§ 95. When pus, in its various stages of formation, is kept in a glass, at rest, for about ten hours, it divides into two layers;‡ the upper of these is the

* The form and elementary organic constitution of the pus-globule become exceedingly distinct in a solution of common kitchen salt.

† I am unacquainted with the form of pus-globule described in this paragraph.—*G. G.*

‡ This is not always the case. The pus of which the particles are shewn in fig. 258 was taken from an abscess at the end of February, and now (April 1) the matter is throughout homogeneous, never having had any supernatant serum. When a quantity of this pus was dried and heated on paper no greasy stain was produced.

In some observations which Mr. Siddall and I made on the generation of infusory animalcules in the fluids of mammals, we could detect no animalcules in pure blood, however long it might be kept,—not even when putrefaction was far advanced. But they were soon generated when water was added either to more diffluent, and is of a pale yellow or very light brown colour, from translucent to transparent, and occasionally covered with oil-globules; this is the *serum of the pus.* The under-layer is more sluggish, of a yellowish green, or greenish grey colour, in different cases, and now more, now less in quantity than the serum; this layer consists of the pus-globules, mixed with a little serum, and occasionally a number of crystals.

§ 96. Chemically analysed, pus gives different results, according to the quality and age of the fluid, — according as it is true pus or false pus, and as it is mature or immature. In giving an analysis of pus, chemists should never fail to state the source, and all the circumstances connected with the specimen examined. The younger the pus, the larger is the quantity of fibrine it contains (transition-cytoblasts); the more mature the pus, the larger is, in general, the quantity of fatty matter which it contains. This retrograding fluid, consequently, from its origin to its perfect developement, forms a direct contrast to the chyle, in point both of organic and chemical constitution. The chyle is at first a kind of oily emulsion, and fibrine only appears in

fresh or stale blood. The same observations apply to the animal fluids generally, judging from experiments with serum, pus, synovia, &c. The observations were not sufficiently numerous to be quite satisfactory, and they are merely mentioned here as suggesting a curious subject which appears to be deserving of further inquiry, especially in connexion with the theory of generation. It seems not improbable that common water contains the rudiments of animalcules, which blood does not. See what the author says of entozoa having been discovered in the blood of the frog, § 56, p. 64.— *G. G.*

it as it undergoes elaboration; pus, on the contrary, at first is fibrine mingled with a watery fluid; it is in a great measure an oily emulsion at last.

*Relative Admixture, in point of Quantity, of the Three Compound Chemical Principles, and the Advance in the Progress of the Assimilation of the Chyle.**

In the afferent or peripheral lacteals (from the intestines to the mesenteric glands)..	Fat, in maximum quantity (numerous fat or oil-globules). Albumen, in minimum quantity (few or no albuminous granules). Fibrine, altogether wanting.†
In the efferent or central lacteals (from the mesenteric glands to the thoracic duct)...	Fat, in medium quantity (fewer oil-globules). Albumen, in maximum quantity (numerous granules). Fibrine, in minimum quantity (in granules, without the form of cytoblasts).
In the thoracic duct.	Fat, in minimum quantity (few or no oil-globules). Albumen, in medium quantity. Fibrine, in excess (cytoblasts, lymph, and corpuscles).‡

* In this view the water, salts, &c. are not taken any account of, these being presumed to be constant but less essential elements here.

† This cannot be an universal law, for I have occasionally seen a delicate though very distinct clot in chyle obtained from the afferent lacteals.— *G. G.*

‡ More globules exist in the chyle of the mesenteric glands than in that of the thoracic duct, or, indeed, of any other portion of the lacteal vessels whatever; at least, I have always found this to be the case when the lacteals and thoracic duct were turgid with chyle. The globules here mentioned are not fatty, but similar to those contained in the fluid of the thymus. See note, p. 57; and Appendix.— *G. G.*

Decline in the Progress of the Formation of Pus.

In pus beginning to be formed	Fat, in minimum quantity (no oil-globules). Albumen, in minimum (few granules). Fibrine, in maximum (cytoblasts, exudation-corpuscles).
In pus well advanced in its formation	Fat, in medium (few oil-globules). Albumen, in excess (granular pus-globules. Fibrine, in minimum (no new cytoblasts).
In pus quite mature	Fat, in excess (numerous oil-globules). Albumen, in medium quantity (granules of decompounded pus-globules). Fibrine, absent.

§ 97. The corpuscles of pus, before they fall down into granules, are acted upon by acetic acid, in the same manner as the lymph, blood, and exudation-corpuscles; the denser nucleus remains nearly unaltered, whilst the granular capsule becomes perfectly transparent, or is dissolved; and when this happens, the component granules of the nucleus separate from one another.* The nucleus and

* The action of acetic acid on pus-globules is not always the same. If these be quite recent when mixed with the acid, their envelopes will instantly disappear; but if the same pus be kept for some days, the action of the acid will be much fainter; and in pus from chronic abscesses the globules frequently exhibit scarcely any change when treated with the acid, as was the case in the matter represented in fig. 258. Indeed, the operation of several re-agents on fibrine becomes more feeble in proportion to its age as a separate matter, and to its compactness. Acetic acid scarcely affects the old fibrine of an aneurismal sac, though recently clotted fibrine is quickly swollen, made transparent, or

cover of cytoblasts, also differ in their chemical composition, a fact which might have been inferred from their optical diversities, each possessing a different refractive power; nevertheless, both of them appear to be mere modifications of one substance, viz. albumen, and entitled by Koch,* *purium*; by Michelotti,† *puruline*; by Gueterbock,‡ *pyine*; by Jordan,§ *fibrous matter*; and by John,|| *modified albumen*. Pus-globules may be obtained pure by

dissolved by this reagent; and the matter of an old crude tubercle seems to resist the action of the acid altogether, which is by no means the case with recent tubercular deposit. Fibrine, therefore, would appear to undergo modifications in its chemical properties after its separation from the blood; and the ready solubility in acids of the most superficial parts of cells and cytoblasts probably arises from the comparative newness of the fibrinous matter of which the outer parts are composed. It should be remarked, however, that the solubility of fibrine in acetic acid is questionable, for many fibrinous parts which disappear on being mixed with the acid may be brought into view again by the addition of iodine. But this consideration does not affect the fact of the different properties of recent and old fibrinous matter. Some interesting observations on the action of vinegar are given by Dr. Davy in his "Researches," vol. i. p. 376, from which it appears that the solvent power of this acid on the animal textures generally is very limited.—*G. G.*

* F. Koch, dissert. de Observationibus nonnullis Microscopicis Sanguinis Cursum et Inflammationem spectantibus atque de Suppuratione, adjecta Analysi Puris Chemica. Berol. 1825.

† Rossi et Michelotti, Analyse de Pus. Mémoires de Turin pour les années 1805 à 1808.

‡ Gueterbock, de Pure et Granulatione Commentatio Physiol. Berol. 1837.

§ Jordan, Disquisitio evictorum Regni Animal. ac Vegetabil. Elementorum. Gœttingæ 1799, p. 40, und v. Crells chem. Annalen, 1801, St. 9, S. 208.

|| John, chem. Untersuchungen. Berl. 1812. Bd. 2, S. 120.

repeated washings with distilled water; they contain very little inorganic matter; according to Pearson, but the $\frac{1}{3000}$th part, insoluble in alkalis, is soluble in concentrated acids; infusory animalcules* are only observed in the pus that is old.

§ 98. As it is obvious, from what precedes, and from the results of the analysis immediately to be quoted, that not every puriform fluid is true pus, and that true pus itself differs according to its age, maturity, the circumstances under which it has been formed, &c., it follows that those analyses only are of any value which are accompanied by some account of the case, and the subject in which the pus was produced. Vogel,† from the numerous analyses of pus which he has published, assigns the following proximate principles as the essential constituents of the fluid :—

I. Pus-corpuscles or globules.

II. Serum, composed of

1. Water.
2. Animal substances, viz.—
   a. Fat.
   b. Osmazome.
   c. Albumen in solution.
3. Inorganic acids and bases, united into inorganic salts, viz. as constant ingredients, sulphuric acid, and hydrochloric acid; each united with lime, potash, soda, magnesia, and ammonia; and, as occasional ingredients, phosphoric acid,

* See note, p. 92.—*G. G.*

† Vogel, Physiologisch-pathologische Untersuchungen über Eiter und Eiterbildung und die damit verwandten Vorgänge. Erlangen, 1838.

acetic, and lactic, and other organic acids. As a secondary product, the result of incineration, carbonic acid.

4. Scilica and oxide of iron.

Analysis of Pus by J. Martius, Erlangen.

Human pus, from an empyema, the consequence of pleuropneumony. The matter, of which five measures were discharged, was pretty consistent, of a yellowish green colour, and without smell ; examined under the microscope by Professor Rudolff Wagner, it was found to contain numerous granules, from the 200th to the 300th of a Paris line in diameter (these, in all probability, were true pus-globules). Tested chemically, it was found neutral, — it did not affect vegetable blue colours. It consisted of the following:

1. Bases: — Lime, potash, soda, magnesia, and ammonia.
2. Acids: — Phosphoric, hydrochloric, lactic.
3. Indifferent matters: — Fat, albumen, osmazome, gelatine, besides water.

Analysis of Pus by Gueterbock: — the Pus from an Abscess in the Human Breast.

1. Water	86·1
2. Fat only soluble in boiling alcohol	1·6
3. Matters (fat and osmazome) soluble in cold alcohol	4·3
4. Matter soluble neither in hot nor in cold alcohol (albumen, pyine, pus-corpuscles and granules)	7·4
Loss	0·6
	100·

The salts in 100 parts of pus amount to	0·8
Of which there are soluble in water	0·7

Consisting of —

Chloride of sodium, in large proportion

Phosphate of soda	In very small quantity.
Sulphate of soda	
Carbonate of soda	
Hydrochlorate of potash (chloride of potassium)	
Hydrochlorate of lime (chloride of calcium)	
Substances soluble in nitric acid	0·1
Consisting of—	
Phosphate of lime	
Phosphate of magnesia	
Carbonate of lime	
Iron, a trace.	

Analysis of Pus by Koch, without any Indication of its Source, or the Circumstances attending its Production.

1. Water.
2. A peculiar substance (*purium*) contained in the globules.
3. Albumen.
4. Mucus.
5. Osmazome.

In the ashes—

Chloride of sodium, phosphate of lime, carbonate of potash, phosphate of potash (soda?), sulphate of lime, carbonate of lime, phosphate of magnesia, oxide of iron, scilica.

Analysis of Pus from the Uterus of a Mare, according to Gœbel.

The fluid of a yellowish white colour, opaque; specific gravity, 1·019; sluggishly fluent, smooth; of a faint, unpleasant smell, neutral; sinking to the bottom when shaken up with water, coagulating when exposed to heat.

Albumen	7·20
Uncoagulable, gelatiniform animal matter	0·94
Free acids, sulphate (and lactate?) of potash, common culinary salt, phosphate of lime, magnesia, protoxide of iron, and scilica	0·35
Water	91·33

*Analysis of Pus from the Frontal Sinus of a Mule, according to Dumas.**

This pus reddened litmus paper, formed an emulsion with cold water, from which, in the course of a few days, a white flocculent matter precipitated. Raised to the temperature of 70° cent. it formed a white granular coagulum, which, washed with water, exhibited all the properties of an albuminous substance, with the exception that it dissolved readily in hydrochloric acid. The water used in washing it, evaporated, smelt unpleasantly of cheese; the dried residue was a yellow extract, which powerfully attracted moisture from the air, and dissolved in alcohol, with the exception of a few albuminous flocculi: this solution, diluted with water, was not rendered turbid; it contained a free acid, a large quantity of hydrochlorate of soda, and a little phosphate of ammonia. 997 parts of this pus consisted of—

Water	820·0
Albumen	165·0
Animal matter, soluble in alcohol and water (osmazome?); phosphates and hydrochlorates, and free lactic acid †	12·5

* Repert. Gén. d'Anat. et de Physiol. t. iii. p. 47. 1827.

† The specific gravity of pus is a point not adverted to in the text, but which it is as well to notice. According to Dr. Davy, there is considerable variation in the specific gravity of pus, as will appear from the following tabular view of his results:—

Kind of Pus.	Sp. Gr.
Good quality and ordinary consistence: from a case of empyema complicated with pneumathorax	1028
Not quite equable: from an abscess in the thigh	1031
Pretty equable, of moderate consistence: from an abscess of the axilla, in convalescence from erysipilas	1029
From the arm, in convalescence from erysipelas of a dangerous character	1036

False Pus.

§ 99. We are constantly meeting with secreted and exuded fluids, both in man and among the lower animals, which, without more particular examination, and, in especial, without an appeal to the microscope, are mistaken for true pus.* These fluids are, indeed, extremely like pus when viewed by the naked eye, and in chemical composition are not very different from it. Nevertheless, they are produced otherwise than true pus, and their nature is different. On the other hand, we occasionally observe matters deposited upon, and poured over, surfaces which look very unlike proper pus, and which yet are either veritable pus, or a substance most nearly allied to it in constitution.

§ 100. It is the fluid already described, the healthy or laudable pus of writers, which alone is produced under the conditions necessary to reproduction in the animal body: I have, therefore, sometimes spoken of it under the title of *reproductive pus;* and as the corpuscles which compose it generally consist of seven granules, it might also be designated the

From an abscess in the back of a young man	1040
Rather thicker than the healthy pus of an abscess: from a large cavity of the lung in a fatal case of consumption	1042
From a vomica in the lung, in another fatal case of pulmonary consumption	1021

"Researches, Phys. and Anat." vol. ii. p. 466. — *G. G.*

* With the exception, I believe, of Dr. Addison, pathologists in this country have generally, of late years, described softened fibrine as pus, especially with the view of explaining the theory of suppuration. See note, page 28. — *G. G.*

seven-granular pus. The corpuscles of this fluid, previously to their resolution, always belong to the nucleated corpuscles;* they are degenerating cytoblasts. In this constant peculiarity of the pus-corpuscle lies the safest criterion for distinguishing pus from other fluids bearing a nearer or more distant resemblance to it; every fluid which is without the peculiar corpuscles indicated, and which never fail in the pus of healthy wounds, however much this fluid resembles pus in appearance, is not pus in reality, and is incapable of aiding the vital processes of repair and reproduction in which the true pus-globule, in its first state of exudation-globule, is the immediate agent.

§ 101. The *puriform mucus,* which is secreted in the last stage of catarrhal affections, varies according to the kind and amount of reproductive process which the mucous membranes implicated require for their restoration. Should the mucous glands and the mucous follicles be altered in a less degree than the epithelium, which after catarrhs is always reproduced afresh, then the discharge, besides the usual mucus-corpuscles and granules (*fig.* 25, B), contains a large addition of newly-formed small lenticular cells (*fig.* 216), instead of the usual older elements of the epithelium, which are large squamous granulated cells (*fig.* 193, *a; fig.* 220) or cylinders (*figs.* 24, 46, 48, 223). In these newly-formed small lenticular cells the nuclei

* The granules which are included in the nuclei of cells, and which are spoken of by Müller, Schwann, and others, under the title of *nuclear corpuscles* (Kernkörperchen), I name, with Valentin and others, *nucleoli* (Kernchen).

are often recognised with difficulty, and this makes them look extremely like large exudation-corpuscles; from which, however, as they differ essentially, they are soon distinguished. Among these young epithelial cells, we occasionally observe true pus-corpuscles; this happens when any part of the mucous membrane has suffered so much as to require reproduction.

§ 102. *Puriform milk* seldom occurs without an admixture of actual pus-globules, which then proceed from abscesses of the milk-gland.

The *puriform sediment of the urine* is, in different cases, a matter of very different composition; it only contains true pus-globules when the reproductive process is going on in some part of the kidneys, bladder, &c. When we meet with true pus-globules in the urine, therefore, we may be certain that the uropoetic system has suffered a breach of continuity* in some part.† What has now been said

* See note, p. 81.—*G. G.*

† The rejection of undissolved pus by the urine from other parts of the system than those that lie in the immediate track of that fluid, is as untenable a notion as that of purulent metastasis without solution of the corpuscles and rupture of the vessels. As, in fact, speaking generally, no reception of the globules of pus into the circulating fluid is possible without rupture of vessels, it is in vain looking for any thing of the kind in the blood in ordinary cachexies and dyscrasies. Pus-globules, as such, can only occur in the blood (and if they did, it would not follow that they were to be excreted in the same shape by glands) when there has been a wound or injury inflicted,—when a solution in the continuity of the tissues has occurred, which has necessarily implicated veins and lymphatics, as is the case in suppurating sores, in phthisis, and where there are abscesses of internal organs, the lungs, the bowels, &c. In cases where a deteri-

in regard to the puriform characters of mucus, of milk, and of urine, applies to all the other secreted fluids.

The Fluids of Bullæ, Phlyctenæ, and Pustules.

§ 103. In the vesications produced by scalds, blisters, the inunction of the tartar-emetic ointment, in superficial aphthæ, in the smallpox and cowpox eruptions in their first periods, &c. &c., the fluid exuded

oration of the juices appears to depend on the absorption of pus, it is not pus-globules as such that deteriorate the blood, but the chemical qualities of the pus which has been taken up, independently of every thing like *form*, in its component elements. Finally, pus absorbed from any one part of the animal body can never be deposited in the shape of pus, and by metastasis in any other part, inasmuch as pus once detached from the living surfaces that produced it is a matter no longer possessed of vitality, and incapable of evolving cytoblasts; pus-globules once resolved into their elements, or dissolved, cease obviously to be pus: and this they must be, as we have seen, before they can be absorbed in quantity into the system, except in those cases in which a substance *like pus* is formed in the immediate channels of the circulation, as it is liable to be in phlebitis in all its shapes.

[In phlebitis it is difficult to conceive how pus can enter the circulation, for the veins are shut up by clots between the diseased and healthy parts. A vast number of cases, usually comprehended under the term phlebitis, would appear rather to be examples of stagnation, clotting, and softening of fibrine. As to the occurrence of pus-globules in the blood, certain large white globules may be detected under the microscope in the blood of all the vertebrate animals; and in some febrile affections pus-globules, or their similitude, occur in unusual numbers in the blood. A small quantity of pus introduced into the blood, into the cellular tissue, or into a serous cavity, generally predisposes in a remarkable manner to the suppurative action, although other foreign bodies, as iron nails, or common shot, do not produce this effect. I have made many experiments on this subject is a serum with albuminous granules,* so long as the texture of the cutis remains uninjured, because the reproduction of the cuticle takes place without suppuration. Should the cutis suffer, however, then suppuration and cicatrization become necessary. It is on this account that we first observe true pus with pus-corpuscles produced in the suppurative stage of smallpox, when, through the intensity of the local inflammation and the contact of the smallpox virus, the subjacent corium is injured in its texture. In the modified or serous smallpox, the suppurative stage does not occur, in consequence of the local inflammation wanting power to cause destruction in the true skin.

Fluid of Ulcers (Ichor).

§ 104. In the discharge of sores, true pus-corpuscles are only discovered when there are parts of the ulcerated surface upon which healthy exudation, and the formation of cytoblasts are pro-

with dogs and cats. In pus produced by inflammation within the animal, the bad effect seems to be prevented by the assiduous manner in which nature isolates the matter from the neighbouring tissues; and in those cases in which the suppurative action becomes general, affecting many organs, as in the so-called metastases, there is commonly little or no deposition of coagulated lymph circumscribing the purulent deposits, whether on the surface of a stump after amputation, or in the substance of an organ. In fine, it appears to me to follow, from the experiments just mentioned, that the contact of pus with the blood or tissues predisposes to suppuration generally — "a little leaven leaveneth the whole lump." — *G. G.*]

* [The fluid of a large blister, set aside in a clean vessel for a time, will often, if not generally, be found to have a delicate coagulum formed in it.]

ceeding, as means of repairing the breach of continuity. If this be not the case, — if the entire ulcerous surface be in an unhealthy state, then the secreted serum contains ichor-corpuscles, with granules, in variable quantity; and when the sore is of the phagedenic kind, larger or smaller detached shreds of the structures implicated, in the shape of filaments and fibres, cartilage-corpuscles, and the like; occasionally, also, oil-globules and crystals. This fluid is of very different colours in different cases, and is generally much thinner than good pus. An [ill-conditioned and unhealing] sore is a wound with a surface incapable of throwing out or organising plastic lymph, bedewed with an altered serous fluid — *ichor*, in technical language — destructive of any exudation that may be produced. This ichor seems even to irritate and eat farther into the tender surface of the wound, and to cause the destruction of the most superficial vessels, which leads to the discharge of small quantities of blood, which is immediately discoloured and so much changed that the liquor sanguinis rarely coagulates save in granules, and the blood-globules appear variously puffed up or crumpled together, superficially corroded or broken down into irregular pieces. The blood-globules thus altered are denominated *ichor-corpuscles* (*fig.* 9, *d*; *fig.* 10, *c*, *d*); they are very commonly covered with granules loosely or more intimately attached to them; they are, probably, better studied in the discharge of glanders than in any other, this consisting in great part of them. When the unhealthy surface of a sore is turned into a fresh wound, either by the removal of the surface with the knife or the destruction of this, together with the discharge by means of the actual or potential cautery, under otherwise favourable circumstances reproductive suppuration is established.

*Contents of Cysts, or Morbid closed Cavities.**

§ 105. It is not uncommon to meet with matters of very different descriptions deposited in cysts or membranous sacs in various parts of the body. The including sacs are organised in different degrees, and are to be regarded as of common origin with their contents; both alike are products of a process of transudation, and they, therefore, bear the same relations to each other, and generally, as do the villous adventitious membranes of serous cavities and the naturally shut sacs, in the various stages of their organisation (§ 79–87; *fig.* 17–21). The contents may exhibit every degree of consistency and organisation, and present all the forms of the elements of the animal body.

§ 106. The contents of accidental cysts are in one case serum, with a variety of substances in solution, or diffused through it. Besides granular matter, crystals of different salts are frequently met with, particularly in the cysts of glandular structures, rhomboidal horny laminæ, often in such quantity that the fluid glistens with something of a pearly or metallic lustre. Very commonly, also, another substance,—the *cyst-corpuscle*, which is very apt to

* The heterogeneous contents of an ovarian cyst are exhibited in *fig.* 256. Some distinct cells appear containing minute spherules, and there are many oval nucleated corpuscles, smaller than the cells.— *G. G.*

be mistaken for the pus-corpuscle, is encountered in the fluid of cysts. Cyst-corpuscles are generally completely round, but little transparent, of a yellowish green, a greyish or brown colour, from the 300th to the 15th of a line in diameter, and they consist of granules rolled together without a nucleus (*fig.* 9, *c*; *fig.* 10, *l*, *G. G.'s fig.* 261, *c*). They, therefore, belong to the granular or aggregation-corpuscles; and they not only resemble the mucus-corpuscles (*fig.* 25, B), and the aggregated pigmentary corpuscles (*fig.* 32, 1), but often seem to form a medium of transition into these last. Under certain circumstances, the nature of which are unknown to me, these corpuscles are flattened and lenticular, and then scarcely larger than the fiftieth of a line in diameter (*fig.* 10, *e*, *f*). These bodies are, also, often seen covered on the surface with the granules of the fluid.*

§ 107. When cysts contain what appears to be blood, the fluid is generally of the consistence of blood that has been stirred or beaten; which, indeed, it greatly resembles: the fluid is not, however, blood in the strict sense of the word; it appears rather to be the product of a continued exudation of the liquor sanguinis. The exudation-corpuscles are then of a chocolate colour, as is the serum also,—larger than blood-corpuscles, and, in point of organisation, they

* The comparison of the pus-globules of the frog with its blood-globules is very important in respect to the theory of the formation of pus. They bear a very close resemblance to the flat, aggregated corpuscles above described; but they contain a distinct granular nucleus; in diameter they measure about five-sixths of that of the blood-globules.

[I have never succeeded in establishing suppuration in frogs. However injured, the parts produced no purulent matter.—*G. G.*]

correspond with those of serous cavities.* Such cysts, of considerable size, are frequently found in the ovaries of women and the domestic animals, in the kidneys, &c.†

§ 108. Encysted abscesses, or purulent deposits of glandular and other parts, contain in one case true, and in another false, pus; in a third case, again, the included matter looks like mashed potato, and consists of exudation-corpuscles, which often remain long unchanged after the removal by absorption of the serum, as in scrofulous glandular swellings, and in false or cytoblast tubercles, which, in the ox particularly, occur so commonly, and sooner or later go on to suppuration, — in the lungs, for instance, where they then form *vomicæ.*

§ 109. The *induration* of glandular organs especially, in consequence of plastic exudation into

* In the body of a female 48 years of age, which was examined by the author in the year 1837, two enormous cysts of this kind were discovered, one of them lying between the transversus and internal oblique abdominal muscles, and containing upwards of twenty Bernese measures of fluid; the other and smaller being situated between the diaphragm and transverse arch of the colon. The parietes of these cysts were composed of an organised layer of fibrinous matter half an inch in thickness, covered internally with extensive projecting villi, and also with many hydatids; the free-corpuscles in the fluid of these last measured the 170th of a Paris line in diameter. The isolated portions of the exudation were also organised, and shewed the general chemical properties of fibrine; they were dissolved by acetic acid, and again precipitated by hydroferrocyanate of potash, alcohol, and heat.

† The fluid from an ovarian cyst of a mare weighed in one case 11 pounds; that from a cyst in the kidney of a fatted bullock, 14½ pounds.

their tissues (infiltrated tubercle), often consists for a long time of exudation-corpuscles, and remain in the shape of a nearly dry substance after the resorption of the serum with which it was at first abundantly mixed; it is much disposed to run into suppuration, but is susceptible, by a further process of organisation, of conversion into true fibrous tubercle, which composes a cicatriform substance,—a substance like the cicatrices of cutaneous wounds, and consists of cellular and granular fibres, occasionally of imperfectly formed filaments.*

As the result of an analysis of the caseiform tubercular matter, undertaken by M. Hecht, 6 grammes were found to consist of 14 decigrammes of albumen, 12 decigrammes of gelatine, 18 decigrammes of fibrine; water and loss, 16 decigrammes.

Organisation of the Exudation in Suppurating Wounds (Granulation, Cicatrization).

§ 110. As already stated (§ 31–42), the formation of cytoblasts is the general principle of *genesis or origin*, and the formation of cells the general principle of *evolution* in all the elementary parts of the animal organism possessed of determinate forms. Albumen, as the matter susceptible of vitality, quickened and endowed with formative power in the shape of liquid fibrine, is, however, the one universal genetic fluid, — the *cytoblastema* from which and in which animal cytoblasts are produced, the seed and

* From the above, it is evident that the author uses the word *tubercle* in another and a much wider sense than that in which it is employed in this country. *Vide* farther on this subject, § 310 *et sequent.*—*G. G.*

the soil at once, as it were. The same substance, in all probability, exists in a modified condition in the vital fluids of plants, especially at those places where the formation of cytoblasts is going on. The visible manifestation of the common principle of life connected with organic matter is the formation of cells included one within the other; that of organic matter susceptible of vital endowment is the formation of granules. The presence of life in organic fluids is proclaimed by the enduring presence of ternary and quaternary compounds.

§ 111. In all essential particulars we find a repetition of the process which we have already followed in the organisation of the plastic exudation of serous cavities (§ 82, 88), in the formation of the substance of cicatrices; there is this difference, however, that in the organisation of the new product complexity must be expected, by so much the greater as the tissues to be repaired are of dissimilar nature, and that the particles and masses of fibrine, mingled with the serum, instead of being dissolved as they are in close cavities, are transformed or degenerate into pus,—an event which also happens in regard to the exudation of shut cavities, so often as the air finds access to them soon after exudation has occurred. When adventitious, morbid cysts, which have existed for years, enclosing all the while fluids of a nature very different from pus, are opened, suppuration generally immediately sets in; the lining membrane of the cavity is thrown off, and the space now changed to an open wound is gradually closed by granulation. As the access of the atmosphere, generally speaking, proves favourable to the occurrence of reproductive purulent formation, so true pus is usually only found in situations in contact with the air,* whilst the contents of close cysts, filled with puriform matter, are generally no more than aggregation or cyst-corpuscles (§ 35, and 106). Exudation from the surface of a wound goes on continually until it is completely healed up; and as organisation begins immediately in the exudation, the fibrine first poured out, and nearest the exuding surface, must be at once completely organised, whilst exudation is still going on in the interior of the sore upon the granulating surface.

With regard to the mode in which exudation takes place, the plastic lymph coagulates as fast as it is thrown out, and in a few minutes composes a layer of unorganised vitreous substance, investing the entire surface of the wound. Half-an-hour later this is found transformed into an imperfect epithelium,—the wound appears covered with a delicate membrane, made up of exudation-corpuscles arranged side by side, and under the microscope appearing tessellated, or like a piece of pavement formed of polygonal pieces; the nuclei of the several corpuscles are also now perceived, and the new membrane acquires a passing resemblance to the appearances seen in *fig.* 47. This most immediate layer now becomes transiently true epithelium, whilst the nucleus, at the same time and under circumstances

* In a preceding page the author asserts this more unequivocally. Dr. Davy could obtain no air from the pus of abscesses ("Researches, Phy. and Anat." vol. ii. p. 462); and I am not aware that it has ever been proved that air has access to many suppurating sacs in which true pus is produced.—*G. G.*

with the precise nature of which I am not yet fully acquainted, undergoes three different alterations, viz. 1, it becomes granulated; or, 2, a clear vesicle is formed on the cytoblast; or, 3, a nucleolus appears in the nucleus, rounded cells are formed about the exudation-corpuscles, and the exudation or cytoblast-coverings become cell-coverings, which, were they permanent, would compose a true epithelium (*fig.* 215, *c*). The formation arrived at this stage is already an integral part of the body where it is evolved, being included within the common boundary of the organism, and participating in its general states and operations. The cytoblasts which are remote from the surface of the wound, in the meantime retrograde (§ 93); their enveloping membranes crack (§ 94, *fig.* 206), and the masses into which they divide become granules (§ 94); the nucleus farther splits into from two to four granules, and the cytoblast membrane is transformed to a pus-membrane (*fig.* 9, *b*), which is now foreign, and felt to be foreign, to the organism. The pus-globules separate and become diffused through the serum; they fall, at length, into granules, and are gradually removed from the wound, whilst the general mass of pus included within it, from the granulating surface outwards, exhibits the various transition stages from the perfect exudation to the ripe pus-globule.

§ 112. The cellular layer, which now covers the surface of the wound, as a living, organised portion of the body, is competent to carry on the process of transudation and reparation; over and in contact with it a new layer of exudation-globules is thrown out, which, undergoing the transformations just described, come in their turn to form a membraniform cellular layer; over which a layer of pus-corpuscles is deposited as before, and so the process goes on.

§ 113. In the successive evolutions of these cellular laminæ, the newly-formed unite with the older cells to form a continuous cellular substance, which is by and by converted into various kinds of cicatrix,—cellular substance, bone, tendon, &c.; or, at all events, a matter which replaces cellular tissue, bone, tendon, skin, &c.

Granulation.

§ 114. The cellular substance produced in this manner forms what are called the *granulations* of wounds; in the course of repair and suppuration going on granulations are scattered over the surface of a healthy healing sore, in the shape of blood-red rounded points, very much as we see the surface of a close cauliflower covered with minute warty tubercles. The bright red colour of healthy granulations does not depend on the numerous newly-formed vessels, filled with blood (§ 86), alone; the cells themselves, especially those most recently evolved, are of nearly as deep a red colour as the blood-globules; and the superficial bleeding which follows even the slightest touch of the granulating surface, does not proceed from blood shed from the newly-formed vessels only: the red fluid, besides blood-globules shed in this manner, consists in part also of ruddy cytoblasts, newly developed red-coloured cells, pale granules, and reddish serum.*

It is a common property of animal cytoblasts, that they present a red colour on their first formation, and in contact with oxygen; but this hue they lose again, whether they advance to perfect developement and become integral parts of a living tissue, or die and degenerate, as they do when they are cast loose and form pus-globules.

§ 115. A thin perpendicular slice of the newly-formed substance of a suppurating wound generally shews the different stages of transition from the momentary vitreous substance of the superficies, and the layer of exudation-corpuscles immediately beneath it, to the almost perfectly formed supplementary tissue of the deeper portions; the different laminæ, however, are never so distinct here as they are in other situations —for example, in the secondarily engendered cellular substance composing the adhesions and false membranes of close cavities lined with serous surfaces (*fig.* 17, 18, 19.) The newly-formed vessels present themselves in such relative connexion with the nearest uninjured parts of the body, that they appear to form a normal portion of the peripheral vascular expansion; the newly-formed vessels, and probably nerves also, compose terminal festoons or loops, and form a kind of foundation for the granulations in the same manner very nearly as the terminal loops of the vessels and nerves do

* It is difficult to say whether this colour of the cytoblasts is acquired from contact with the atmosphere, or is original; it is next to impossible to make observations upon the formation of granulations with the exclusion of the atmospheric air.

for the papillary bodies of the cutis. Of these terminal loops, the representations in *figs.* 92, 93, 97, and 98, are calculated to convey a very good idea. The relations of the newly-formed nerves are traced with much more difficulty than those of the newly-produced blood-vessels.

Cicatrization.

§ 116. When the cavity of the wound is at length more or less perfectly filled up by the granulations and the supplementary tissues they have formed, the last layers of exudation poured out undergo transformation into an imperfect kind of corium, and finally, to a cuticle or epidermis of the same description. In place of an exuding wound we have, in the end, a deeper and then a paler violet-coloured depressed cicatrix. Even after complete cicatrization, the newly-developed tissues are never so determinate and distinct as the primary tissues in their immediate vicinity.

The various supplementary tissues are, generally speaking, formed in the same manner as the primary tissues are engendered in the embryo, *i. e.* from a cellular substance.

OF THE PRIMARY ORGANIZING PROCESS IN THE IMPREGNATED OVUM.

§ 117. It is not my intention to enter upon the consideration of the developement of the several organs of animals in this place ; this subject belongs to the Physiology. It is within my province, however, to describe the evolution and mode of formation of the various elementary parts and tissues that enter into the constitution of animal bodies.

The Fœtal Ovum.

§ 118. Soon after the appearance of the ovaries in the embryo of the human subject and mammalia, we observe preparations made for the production of new individuals. These preparations, indeed, only come into play at a much later period, viz. when manhood or the adult age is attained; but, at the earliest period, eggs are discovered included in that which was but just an egg, and these in their turn are endowed in perpetuity with the wonderful heritage of evolving their like.

When the investing membrane of the extremely delicate ovaries of young embryos is torn through by means of a couple of pairs of fine forceps, and their contents, after being carefully divided into pieces, are mixed with a solution of sugar or a neutral salt and brought into the field of the microscope, numbers of extremely delicate transparent vesicles are perceived. These are readily distinguished from the spongy substance of the ovary, which looks loose and full of cysts, and finely granular.

The vesicles, on the contrary, are perceived as transparent bladders filled with a homogeneous fluid, which to chemical re-agents comports itself like albumen, and including a darker mass often visibly attached to the inner aspect of the walls of the vesicle, and appearing in the guise of a rounded spot with an indefinite outline.

§ 119. The cells of the ovary (*fig.* 28, *a*) in which these vesicles lie embedded, appear to be of equal sizes; they are round, extremely pale, and generally include several nuclei; they are connected by means of a serous fluid, or an extremely delicate intercellular substance, and cover the vesicles lying flat upon the glass plate in such a way that at first they seem as if they were included within these (a', a'', a''').

§ 120. When we succeed, by means of motion in different directions, and the application of a delicate hair pencil, in freeing the easily destructible vesicle from the surrounding cysts, its rounded spot comes into view upon its middle or towards one of its edges, and the object presents itself in the guise of a *cell*, the nucleus not homogeneous. Whether this cell becomes the Graafian vesicle, which, in the adult, includes the ovum, or is the rudiment of the ovum itself, I do not venture to say; for it stands as a simple cell in the same rank, as it were, with newly formed cells at large (*fig.* 216). In all likelihood the primary cell is the representative of the ovum, which then forms the zona pellucida and Graafian follicle; or the delicate vesicle is the albuminous envelope which Krause has indicated as the covering of the ovum in the ovary of adults.* This latter view would be in accordance with that of Schwann,† who regards the vesicular part as the primary cell.

The Unimpregnated Ovum in the Adult.

§ 121. In older fœtuses the several parts of the ovum may be demonstrated such as they present

* Müller's "Archiv," 1837. S. 27.

† "Mikroscopische Untersuchungen," &c. Berlin, 1839. S. 48.

themselves in the ovaries of adults. The substance of the ovary, which is now of firmer consistence, includes numerous cysts of various sizes, generally from the $\frac{1}{8}$th to the $\frac{1}{4}$th of a line in diameter, but in some animals much more; as in the cow, where they are $1\frac{1}{2}$ line in diameter. These cysts are generally globular in figure, and are provided with a proper indusium. They form the Graafian vesicles or Graafian follicles (*fig.* 27, *a*), in which the Graafian ovula (*c*), surrounded by the cells of the follicular body (*b*), are contained. This is surrounded immediately by Krause's membrane of the albumen, which is generally obvious in the ovum of the cow, but was not visible in the subject of the drawing (*fig.* 27); it had probably burst. Within this albuminous membrane, and surrounded by fluid albumen, the vitellus or yolk is suspended at perfect freedom. This vitellus consists of two globular-shaped vesicles, the outer of which, the ZONA PELLUCIDA (*c*), is of considerable thickness, but without manifest structure; whilst the second, the proper VITELLINE MEMBRANE* (*d*), of extreme delicacy, looks like an epithelium of the former, and includes immediately the finely granular vitellary substance (*e*). The flat-shaped GERMINAL VESICLE (*f*) is generally found attached to the inner aspect of the vitelline membrane; sometimes, however, it is met with free amidst the vitellary matter. The middle of the germinal vesicle is occupied by the GERMINAL SPOT (*g*), a structure which bears the closest possible resemblance to the true pus-globule.

* Vide Note under next paragraph, § 122.

Origin of the Ovum.

§ 122. The ovum is formed either in accordance with the law of involution, so that the albuminous membrane with the included nucleus forms the parent cell, in which the nucleus, as secondary cell, is transformed into the zona pellucida and vitelline membrane (the latter, perchance, no more than a layer of albumen*), the contents of this secondary cell being the yolk, whose nucleus is the germinal vesicle, and whose nucleolus is the germinal spot; just as the germinal vesicle, when the nucleolus of the germinal spot appears, must be regarded as constituting the innermost cell. Or, otherwise, the germinal spot is already present in the original albuminous cell, the nucleus of which it forms as cell-germ, and upon and around this the germinal vesicle is evolved as the secondary cell, according to the ordinary laws of organic developement. In all probability the germinal spot, as the cytoblast or organic germ, is the primary formation, from which the germinal vesicle is evolved in the usual way, the vitelline and albuminous membranes being subsequently produced around this. In either case, cell within cell is very obviously included in the Graafian vesicle; and this, the albuminous membrane, the vitellary membrane, and the capsule of the germinal vesicle, are to be viewed as the membranes of so many cells; the first of these being the Graafian vesicle with the ovum; the second, the homogeneous albumen ovi with the vitellus; the

* On the formation of the ovum, *vide* the "Elements of Physiology" of Dr. Rud. Wagner, by R. Willis, M.D., p. 36, *et seq.*

third, the vitellus with the germinal vesicle; and the fourth, a homogeneous, and, according to Wagner, also an albuminous fluid, including the germinal spot. Nor is this all: the germinal spot is itself even as certainly a compound body,—a cytoblast or organic germ, which, supposing the germinal vesicle actually to disappear from the fecundated ovum, is evolved from the germinal membrane at the same spot.

Earliest period of Developement in the Fecundated Ovum, and Origin of the Embryo in the Incubated Egg.

§ 123. In all probability, the germinal vesicle is formed simultaneously with the Graafian follicle; and the yolk-cells are only produced subsequently around the germinal vesicle. The yolk is at first very small, and its capsule embraces the germinal vesicle closely; it, therefore, increases in an infinitely greater ratio than the germinal vesicle. Cell-germs arise, which surround the germinal vesicle and prove the first rudiments of the germinal membrane; at the same time other cell-germs appear, which are rapidly evolved into white cells—the vitelline cells for the formation of the vitelline cavity. On the inner aspect of the growing vitellary membrane, with the exception of the spot which is occupied by the germinal vesicle and the rudiment of the germinal membrane, arise other yellow cells, apparently as products of the vitellary membrane, which constitute the proper vitellary matter. Whilst these cells are produced, the exudation from the inner aspect of the vitellary membrane continues; there is a perpetual production of yellow-coloured cell-germs between the vitellary membrane and the mass of cell-germs already formed, until the growth of the yolk is complete. These yellow cell-germs, including one another in concentrically disposed layers, also include the first-formed white cells, which are in immediate contact with the rudimentary germinal membrane; and, whilst the number and volume of these last increase, the middle point of the white central cells of the vitellary cavity recedes more and more from the germinal membrane and germinal vesicle, yet is ever in connexion with them: so that between the vitellary cavity and the proligerous disc there is at length a canal or passage of communication established.* At length the ovum quits the ovary and the germinal vesicle disappears. In its place we have then the disc-shaped germinal membrane produced, which by and by divides into two layers; the outer being distinguished as the *serous* layer, and the inner, the *mucous* layer, whilst the space between them is spoken of as the *vascular* layer. From the serous layer are evolved the animal and external organs; from the mucous layer arise the organic and internal parts; from the vascular intermediate layer, as the name implies, the blood and vascular system are produced. The germinal membrane consists of globular cells with nuclei and granules; it grows by the growth and increase in number of these cells.

* See an excellent figure of the parts here described in Wagner's "Elements of Physiology," by Willis, p. 84.

In the eggs of fowls that have been incubated for about sixteen hours we begin to perceive the separation into layers in the germinal membrane; at the same time also we distinguish a difference in their constituent elementary cells: the cells of the outer serous lamina are highly transparent, and inclose a limpid fluid and single nuclei with nucleoli and a few granules, very much in the manner of connected epithelial cells. The inner lamina, in an abundant and softer intercellular substance, includes cells with various globular dark nuclei and fine granules.* In the middle of the germinal membrane, betwixt its laminæ, now increased in size by the apposition and growth of cells, arises the *area pellucida*, a transparent spot or space consisting of smaller cells and granules; and here it is that the embryo is formed by the inversion of the middle portion of the germinal membrane, which has increased in thickness, and the separation of the edges of the same part. The embryo therefore, as well as all the parts about it, is formed exclusively of cells. In the middle included layer of the germinal membrane it is that the blood-vessels are engendered; these partly expand in the vitellary cavity, and then begins the period of the nourishment of the embryo from the yolk; but without reference to this, every rudiment of a new part, as also the growth and evolution of the parts already commenced, take place by the further production of cell-germs and cells, and of structures composed by these. In the interior of the rudiments of

* See a fine figure of these cells in the work of Wagner just quoted, p. 212.

the vascular system are evolved the red-coloured permanent* cytoblasts, organic germs or blood-globules, the liquor sanguinis, &c.: in a word, the blood. The further developement of the different compound parts will be treated of at length in the immediately following histological portion of this work.

FORMATION OF THE VARIOUS COMPOUND PARTS AND TISSUES FROM CELLS.

§ 124. Should my notions in regard to the transformation of vegetable albumen, under the assimilating and vitalising forces of plants, into a fluid gluten or general cytoblastema, be confirmed, we should have the same accordance in the assimilation and chemical metamorphoses of assimilable matters in the animal and vegetable kingdom, which has already been shewn by Schwann to obtain in reference to their structure and mode of growth. The fluid gluten of plants would then correspond to the fluid fibrine of animals; and it is not uninteresting to observe that both of these matters are distinguished by their power to form granules. A

* The word *permanent* here is to be taken in a restricted sense. It is not meant that the blood-globules themselves undergo no change: they are perpetually changing, being resolved so as to pass into the elements probably of all the tissues; and such portions of these tissues as are not unfitted for the uses of the economy, when they come to be changed and renewed, are very probably associated again, and again formed into blood-globules. The blood-globules are only *permanent* as regards their form: as blood-globules, they are at the acmé of their developement; without solution and disintegration, without losing shape and consistence, they cannot become or pass into other tissues.

parallel has already been drawn between the sap of the roots of vegetables and the chyle of animals, betwixt the circulating fluid or blood of animals and the sap of the trunk or stem, branches, and leaves of plants, but without any very particular investigation of the nature of the resemblance between them. The united researches of physiologists and chemists ought to resolve this problem, the more speedily now, as the majority of the latter have very recently shewn nothing like the old indisposition to grapple with the difficulties of organic chemistry. The mutability of organic elements no longer rebuts inquirers, and the advances which have lately been made in the organic have been no less signal than those which have long marked the cultivation of the inorganic branch of chemical science. Should the idea be confirmed that the *blood* of plants, like that of animals, contains peculiar corpuscles* as one of its essential elements, then will the physiology of vegetables and of animals be equally advanced by researches in the one or in the other; every new discovery in the one will be the herald of a corresponding discovery in the other; and the science of organic life will thus acquire a double impetus in its onward progress. The daily increase of our knowledge in regard to the analogies in the morphological life of plants and animals gives every reason to believe that such will truly be found to be the case. At all events, the inquiries of Schleiden and

* A very important acquisition for the doctrine of the *pneumatic relations,* or *respiration of vegetables,* of which so little is yet known.

Schwann have opened up a new and yet untrodden field for investigation—a kind of continent in physiology, the existence of which was long suspected, though never demonstrated, but which now lies open to the physiologist and the chemist, with every promise of a most ample harvest as the reward of any pains they may bestow in cultivating its soil.

§ 125. Many particulars bearing upon organization and reorganization by means of evolved cells having now been mentioned, we may next proceed to examine more closely the special relations of the cells in the constitution of the various tissues of the human and animal body.

Just as we see the same building material, after it is worked, put together and employed to the most varied ends, used to erect the most dissimilar fabrics, so do we observe cells in the animal body modelled and arranged, after a plan which is partly known, in the most various manners. The cell which is the product of the living cytoblast is, in fact, a material prepared beforehand, and available for the most varied purposes in the organic fabric. From the nearly passive constituent, which in many cases may be held as fulfilling its destiny merely by occupying space, to the organ by which man is fitted to approach his Maker, every part of the body has one common mode of origin, even as organisms of all kinds arise from single cells. In the progressively forming organism every care is taken that plastic matter, in adequate quantity and of proper quality, according to its wants, be furnished. Hidden life in the fluid, in the shapable, precedes revealed life in the solid, in the shapen. Fat, albumen and fibrine, or assimilable, nutritive and plastic matter, form the three first distinguishable grades towards the capacity to assume determinate forms and shapes in man and animals; after these follows the formation of cytoblasts, the universal elementary type of all compound constituent parts; then come the formation of cells, the co-ordination of cells, and the metamorphosis of cells.

Of the different Constitutions of Cells.

§ 126. In the same way as the germinal vesicle is connected with the inner aspect of the vitelline membrane, the cytoblast is generally seen as the cell-nucleus adhering to a point of the cell-capsule which has arisen upon it, and increased in size by the progressive accumulation of an included fluid. The cytoblast only appears in the middle of the cell—1st. When it has been accidentally detached from its connexion with the inner aspect of the capsule, and this is an event that rarely happens. 2d. When the specifically heavier cytoblast, descending through the fluid of the cell, sinks to the lowest point,—examined from above, it of course appears to occupy the middle of the cell. 3d. When the cell is flattened, in which case the cytoblast always lies more or less truly in the middle of the hemisphere of the cell-capsule, depressed into the shape of a disc. When in the course of microscopical observations on cells, the cytoblast or nucleus is observed very generally on the edge of the vesicle, in all likelihood globular cells of recent formation are in the field (*figs.* 216 and 227); conviction of the truth of which, or otherwise, may be obtained by moving the object, and shading the light on one side. If such young cells swing free amidst or upon a limpid medium, then the subjacent nuclei will be seen to swing something in the manner of a pendulum, when the object bearer is slightly shaken; and those within the vesicles can be seen to move hither and thither across their diameter; in general, too, the vesicle is smaller relatively to the nucleus, the younger the cell is. When the primarily fluid contents of the cell augment, or imbibe water by endosmose from surrounding media, then the vesicle increases proportionately; but when the cell gives water to a surrounding medium by exosmose, then it shrinks, and, in some rare instances, becomes irregular and wrinkled: generally it becomes flattened, the point of the vesicle opposite to that at which the nucleus is attached approaching this, and the cell passing through the changes of form which are shewn in *figs.* 227 and 228, *a–f.*

§ 127. From the fluid contents of cells, albuminous granules are frequently precipitated, which, when they are very minute, and not in too great numbers, generally exhibit lively molecular movements. Should the cell lose its water after a copious precipitation of albumen, it appears granular, and may be confounded with the aggregation-corpuscle (§ 35); but in general only the older, flat and detached cells, are properly granular (*fig.* 220).

§ 128. Occasionally the cell-capsule bursts and disappears, leaving the nucleus behind; more commonly, and in the horny tissues regularly, the nucleus disappears, and then the flattened cell becomes a *scale* or *lamella* (*figs.* 34 and 41); when this happens in the globular cell, then the *vesicle* is produced (*figs.* 208 and 209). Cell-nuclei are frequently granular, those of the cells of cartilage and of cellular fibres are so commonly. Under what circumstances the nucleus and the nucleolus increase, whilst in the old nucleolus a new one arises, by which the nucleus becomes a cell, and also how the contrary of all this occurs, must be determined by future inquiries. The nucleolus, too, occasionally, perhaps more commonly than is imagined, is granular; this is the case regularly in the ganglionic cell (*fig.* 89, 2, 3), and in the ovum, if the germinal spot be taken as the indication of the cell-nucleolus.

§ 129. Cells vary in size according to the degree of their developement, according to their destination, &c.; they are seen of all dimensions, between that of the lymph-granule and the 60th of a Paris line; in the ovum they are a Paris line and more in diameter; next to the ovum they are largest in the cellular cartilages (*fig.* 57), and in those parts of the bones where the nuclei (the bone corpuscles) lie very much isolated (*fig.* 68 at *a*).

§ 130. The form presented by cells is also very various; those that are isolated are generally spherical (*figs.* 216 and 227, *a*), ellipsoidal, egg-shaped, pear-shaped (*figs.* 217 and 89, 2, 4, 6), more rarely kidney-shaped or flattened. When many cells are closely crowded together they become polyhedral; those only that are connected into a membrane, and whose form is flattened or lenticular, those of the cuticle, for example, are polygonal on their edges; generally they are six-sided (*figs.* 215 and 226). Rounded cells heaped together always become flattened at the points of contact, just as we see soap-bubbles when they touch one another (*fig.* 72, *b*); but when the cells, whether piled together or connected into a membrane, do not come into contact immediately, but are separated by an intercellular matter, then may they continue to preserve their original rounded figure, as is the case with the ganglionic cells; or they may become polygonal or polyhedral, as we observe them in different epitheliæ (*fig.* 32, 2, 3; *figs.* 33, 47, and 214).

§ 131. When the cells pass into fibres, they become fusiform (§ 84 and 35), and in their linear connexion form cellular fibres, within which the nuclei are frequently to be observed connected by internuclear fibres (*fig.* 219, *d*); these nuclear fibres perhaps even occur naked (*fig.* 203). When the cell becomes elongated, its vesicle then forms a rounded or pointed, but closed, tube at either end; this, according to Schwann,* is the case in the crystalline lens of the eye, and, according to Gurlt,† in the acicular enamel of the pulp of the tooth. Should the cell only elongate in the form of a tube at one part, it acquires the shape of a club (Schwann, Tab. I. *fig.* 12). Cells undergo elongation in different directions, and form networks with one another, as is seen in the branched pigmentary cells (*fig.* 32, *d*; Schwann, Tab. II. *fig.* 9). Cells increase

* Mikroscop. Untersuch. &c.

† Lehrbuch der verg. Phys. Tab. ii. Fig. 11.

and are developed independently in the vicinity of the capillary vessels, apparently in consequence of endosmotic penetration of the surrounding cytoblastema; but how they are determined to assume such a variety of forms in the composition of the elementary tissues is unknown.

Schwann* gives the following classification of the animal tissues, as the result of his inquiries in their present state:—

1st Class.—Isolated independent cells. To this class belong especially the cells of the various fluids,†—lymph-corpuscles, blood-corpuscles, mucus-corpuscles, pus-corpuscles, &c.

2d Class.—Independent cells united into continuous tissues. To this class belong the whole of the horny tissues and the crystalline lens.

3d Class.—Cells, only the walls of which blend together: cartilage, bone, teeth.

4th Class.—Fibrous cells, or cell-fibres: cellular tissue, sinewy tissue, elastic tissue.

5th Class.—Cells, the walls and cavities of which are alike blended or united: muscles, bones, capillary vessels.

Pigment, Pigmentum nigrum.

§ 132. The substratum of the black pigment consists of minute granules, which, when isolated in a fluid, exhibit molecular motion by so much the

* Op. cit. S. 74.

† These we regard as cytoblasts, not as cells.

more lively as the fluid is volatile,* and which, heaped together, absorb or reflect the rays of light in such a way that the mass, whether viewed by transmitted or direct light, appears of a black-brown colour. The several rounded granules, under a high magnifying power, appear pretty evenly dispersed through a hyaline substance; individually, they are not black and opaque, but transparent (*fig.* 39, *b*, *c*, *d*). The pigmentary granules, as we observe them in the diffluent pigmentary matter of the choroid coat, form aggregation-corpuscles (pigmentary corpuscles), which are less transparent than the mucus and cyst-corpuscle (*fig.* 32, 1, *a*), or they are inclosed in cells, to which they give their black colour. These pigmentary cells are met with either more isolated, or grouped together, as in the skin; or they form membranes made up of polyhedral parts, as in the choroid coat of the eye (*fig.* 32, 2 —at *a a*, some cells are removed from the intercellular substance—3, and *fig.* 33, upon the translucent veins). As a general rule, the nucleus of the pigmentary cell appears clear and transparent, and it frequently includes a small darker nucleolus. Many pigmentary cells undergo elongation in different directions into hollow fibres, which, meeting other pigmentary formations of the same kind, produce a more or less perfect network of star-shaped cells. The nuclei of the multangular pigmentary

* To obtain assurance that this is the case, let a small quantity of any finely granular matter, pigment, dust, any insoluble precipitate, be added to water, oil of turpentine, alcohol, ether, &c., and let the vigour of the motions be compared with the volatility of the fluids successively employed.

cells disappear in horn (*fig.* 35, *b*). Pigmentary matter is met with in every part of a brownish-black or black colour.

Fat Vesicles; Fat Cells.

§ 133. In many parts of the human and animal body, a larger or smaller quantity of fat is very constantly met with. The quantity is generally in proportion to the degree of nutrition. The fat itself exists in the shape of small globular vesicles, and is generally intermixed with the cellular tissue. Collections of these vesicles are encountered particularly between and around the muscles of the eyeball, in the hollow of the orbit, between the muscles of the external ear in mammals,— situations in which they serve as pads or cushions, retaining parts in their relative situations, and aiding them in their actions. A quantity of fat, more or less, is also very regularly found upon the heart, covered immediately by the cardiac reflection of the pericardium, and around the great blood-vessels at their origins and terminations; in the folds of the omentum and mesentery; about the kidneys; within the spinal canal between the periosteum and the dura mater; in the cancelli of the short, and shafts of the long, bones; in the subcutaneous cellular tissue, &c. The fat of the cellular tissue is obviously inclosed in membranous cell-vesicles, in which the nuclei are frequently to be discovered (fat cells). The ordinary fat vesicles measure from the $\frac{1}{100}$th to the $\frac{1}{20}$th of a Paris line in diameter (*fig.* 31, *b*); those of the spinal canal (*a*) are from the $\frac{1}{170}$th to the $\frac{1}{100}$th of a Paris line in dimensions; when they are isolated or are imbedded in a soft intercellular substance they retain their globular figure, but, like all other spherical cells, they become polyhedral when they lie in contact one with another, with no kind of interposed matter (*fig.* 72 *b*).* The consistency of the fat included in the vesicles varies with the ratio between the stearine and elain of which all fat consists; it is very firm in the sheep, where the stea-

* Although the majority of the fat vesicles are circular, a great number of them are of an oval form. The smaller are generally of the former shape, while many of the larger are frequently more or less elliptical. The magnitude of the vesicles is remarkably variable. A very common size is about $\frac{1}{600}$th of an inch in diameter. In the fat vesicles of the omentum of a fœtal calf I observed numberless gradations, from $\frac{1}{4000}$th to $\frac{1}{250}$th of an inch in diameter, although most of them were about $\frac{1}{857}$th of an inch. In the mesentery of a shrewmouse scarcely any fatty matter could be found, but some vesicles were observable, and these were so minute as to measure only from $\frac{1}{6000}$th to $\frac{1}{2000}$th of an inch. They were collected into small clusters. In the peritoneum of a young kitten the majority of the vesicles were about $\frac{1}{600}$th of an inch, but some were only $\frac{1}{4570}$th. These latter occurred in clusters often not larger than the average sized vesicles. In the calf above mentioned the fat appeared to exist within the vesicles in a granular form, the granules being extremely minute, certainly not larger than $\frac{1}{20000}$th of an inch in diameter; some of the large vesicles seemed to be only partially filled with this granular fat. The granules were best seen with a strong transmitted light. In the kitten I could not detect them. In the peritoneum of most young animals, as the fat is deposited in thin layers, the vesicles may be clearly distinguished with a Coddington lens, by extending a bit of the membrane on a slip of glass and making the examination against the light.—*G. G.*

rine predominates, and is called *suet*, or *tallow*; it is much softer in the hog, where the elain is most abundant, and where it is called *lard*.

§ 134. The soft fat of the solidungula is of a yellowish colour, and at 32° F. has a specific gravity of 0·914; it congeals at 48°, and at 90° it becomes fluid; it contains about $3\frac{1}{2}$ per cent of stearine, and $96\frac{1}{2}$ per cent elain. The fat of the hog is white, soft, and melts at a lower temperature; it consists of about 38 per cent stearine, and 62 per cent elain. In the carnivora, the fat is soft, yellowish, and of a peculiar odour. In the dog it is composed of 17 per cent stearine and 73 per cent elain. The fat of the human infant is white, or of a pale citron yellow colour; it is firm, and contains a large proportion of stearine. Fresh animal fat in general is dissolved and taken up by ether without any rupture of the containing vesicles.

Fat defends and isolates the organs of the body, and, as a bad conductor of heat, it tends to preserve the temperature; with abundant food it accumulates in the healthy body; with indifferent and scanty supplies of food, and under the influence of disease, it disappears.

Horn, and Horny Tissues.

§ 135. Chemically considered, HORN comports itself like albumen, but it contains less azote than this substance. Horn forms the principal element in the outermost laminæ of the animal body, viz. the cuticle and the various means for covering and protection, in the shape of nails, claws, hoofs, hair, feathers, spines, scales, plates, &c. The horny substance is transparent, of a yellowish brown hue, hard, and elastic; it softens without dissolving in boiling water; it also softens when exposed to dry heat, and then melts and swells out. With dry distillation it yields carbonate and cyanate of ammonia. Thrown upon an open fire, it burns, swelling up and diffusing a peculiar and well-known disagreeable odour. It is decomposed by concentrated acids and is dissolved by the caustic alkalis with evolution of ammonia. Horn presents itself in the living body as a morbid product, and then frequently in the form of crystalline-looking rhomboidal tables (*fig.* 172); at other times it appears as a congeries of dried cell-scales. The younger epidermic and epithelial cells exhibit the same chemical properties as fibrine.

External Horny Indusiæ.—Epidermis, Epithelium, and Structures connected with them.

§ 136. All the surfaces of the body are covered with the cellulo-membranous layers which constitute the epidermis or epithelium. The epidermis, cuticle, or external covering, of the skin, consists of several layers of cells, which are produced upon the corium, as a consequence of an uninterrupted process of exudation, accompanied by a like continuous formation of cytoblasts and cells. These cells incessantly produced below, are as incessantly thrown off by desquamation above. The most recently produced cells, which of course are those that are in contact with the corium, are like all young cells, spherical in their figure; they become flattened in the same proportion as they approach the superficies: so that when examined on a section they are observed to undergo alterations of figure, from that of a globular cell provided with a nucleus, to that of a flat scale in which no trace of a nucleus appears (*figs.* 227 and 228 *a*, *f*). The innermost layers consequently form soft cellular membranes, the outermost layers constitute hard squamous membranes. The epidermis covers the entire external surface of the body, even the cornea of the eye (*fig.* 41). Rarely, perhaps never, do we find any intercellular matter, or matter interposed between the cells; occasionally, however, a matter of this sort may be suspected in the seat of their formation, upon the surface of the corium, in the mucous layer of Malpighi. The epidermis is pierced at every point by the excretory ducts of the sebaceous and sweat-glands, and, with few exceptions, by the shafts of the hairs also. It always consists of layers by so much the more numerous as the part which it covers is more strongly compressed or constantly rubbed; for example, in the palm of the hand and sole of the foot: among the mammalia it is in general by so much the more delicate the finer and thinner the hair is; but wherever constant and strong friction is endured, the hair disappears, though there the excretory ducts of the cutaneous glands are very much developed (*fig.* 40, *e*, *f*). The hoofs, claws, talons, horns, nails, &c., are not merely connected with the epidermis, but are in fact more strikingly developed portions of this tissue, just as the cutaneous glands and the hairs are involutions of the same.

§ 137. The different tints of colour presented by the common integument depend on the pigmentary matter which enters into its composition; where this is wanting, the epidermis is transparent and colourless, or but very slightly tinged with the portion of pigment which is present in the sebaceous glands and Malpighian body. It is only in the negro that the cells of the cuticle sometimes present themselves with a pretty strong resemblance to the pigmentary cells.

The Sebaceous Glands, the Sweat Glands.

§ 138. These organs are formed from involutions of the cuticle, and when their relation to this tissue is considered, they might be named *inserted horny structures.* We shall speak of the larger glands which are formed in the same way as the sebaceous and sudoriparous glands, such as the mammary glands, in the section which treats particularly of the secreting glands.

§ 139. *Sebaceous Glands.*—All the true glands having excretory ducts, stand in relation either with the epidermis or with the epithelium; or, in other words, they are inversions or involutions of the cuticle or epithelium contained within the substance of the skin or mucous membranes, or penetrating beyond them. These glands severally secrete a peculiar fluid, different from the general circulating fluid, and which are referable to three grand classes —the fatty, the watery, and the mixed.

§ 140. The glands of the external integument are true secreting glands, which, in the simplicity of their structure, nevertheless agree essentially with all others of a more complex organisation. The *sebaceous* glands are either proper in all their parts, or their ducts serve the double office of excretory canals and sheaths for hairs. In the most simple forms they present themselves as club-shaped crypts, which arise on the outer aspect of the common integument as funnel-shaped involved processes of the epidermis, and lie at greater or less depths in the corium. They secrete an unctuous or butyraceous matter,—the sebaceous matter, which contains crystals of stearine (*fig.* 31, *d*), oil-globules (*e*), and pigmentary granules. The origin and developement of the sebaceous glands in the palm of the human fœtus is represented in *fig.* 239. At *a* the epidermis is seen, in the first instance, hemispherically depressed into the substance of the subjacent corium; at *f* the gland is nearly fully formed, and the racemiform glandlets are evolved; the spirally twisted or corkscrew-like excretory duct of the gland, *f*, lies in the substance of the thick corium (see, also, *fig.* 40, *g*, *h*, *i*). In the hide of the horse, also, the sebaceous glands are commonly moriform or botryoidal, from one-tenth to one quarter of a line in diameter; on the scrotum they occur unaccompanied by hairs (*fig.* 44); it is betwixt the semicircular elevations of the cutis, *a*, that the infundibuliform orifices, *b*, of the delicate common excretory ducts, *c*, are encountered; these common ducts generally divide into two branches, *d*, which lead to the same number of particular moriform secreting glands, *e*.

The sebaceous matter is of a brown colour, and contains many pigmentary granules. In the skin of the labia of the mare (*fig.* 45), the glands are more extensively developed; the individual glandular vesicles (*e*) proceed to distinct and wide pedicles (*d*), and there end and unite in the common excernent duct (*c*), which is at the same time the sheath of the hair (*f*). The sebaceous matter is of the kind just indicated. In the prepuce of the stallion (*fig.* 43), the several parts are still farther developed; the cuticle *a* is reflected inwards at *b* in the shape of a funnel, and forms the sheath of the hair and the common excretory duct *c*, into which the efferent canals *f*, *f*, of the elementary glandules *e*, pour their contents. At *d* the sheath of the hair is seen forming or rather surrounding the bulb of the hair; *k* is the excretory duct of the sudoriparous gland *i*, which lies imbedded among the subcutaneous cellular tissue. The sebaceous matter often collects between the folds of the prepuce in large masses of a dirty grey colour, which possess varying degrees of consistency, from that of soft tallow to that of wax, and are soluble, but not so readily as ordinary fat, in ether and boiling alcohol, leaving a residue of albumen and certain saline matters.

In the hog the sebaceous glands are sacculated, and either unilocular, bilocular, or multilocular (*figs.* 160, 161). The smallest vesicles are from the $\frac{1}{100}$th to the $\frac{1}{80}$th, and the excretory canals are about the $\frac{1}{35}$th of a Paris line in diameter. On the snout we observe certain remarkable tactile organs which may be mentioned here, inasmuch as they also secrete sebaceous matter. The organs in question are tactile sacs very copiously supplied with nerves, and having a small bristle traversing their centre; they are about $\frac{1}{6}$th of a Paris line in length and about $\frac{1}{13}$th in breadth, fusiform, and with thick parietes. They open upon the surface of the common integument in a compound rosette-shaped nervous papilla (*fig.* 101); they contain sebaceous matter in their interior, and in the middle a bristle, as said, growing from a bulb, about $\frac{1}{115}$th of a line in thickness, conically pointed, inclosed in a regular sheath, and projecting about $\frac{1}{4}$th of a line beyond the papilla. The sac is inclosed by the nervous bundle which forms the papilla. Other nervous bundles, which lie parallel with the skin, pass in multitudes across the interspaces, and there form abundant reticulations.

The sebaceous glands of the meatus auditorius and of the inner skin of the external ear are greatly developed, and secrete the cerumen or wax of the ear,—a bitter, yellowish-brown, fatty matter. The sebaceous glands are absent in those situations where the skin secretes a mucous fluid, as the nose of the carnivora, the muzzle of the ox, the snout of the hog, &c.

§ 141. The sebaceous matter serves to anoint and preserve the scarf-skin, the hair, horn, &c. soft and pliant; it also serves to a certain extent as a defence against external chemical and mechanical agencies, and has some influence upon the colour of the skin. In the time of heat, especially among female animals, it is poured out in greater quantity and of a stronger odour than at other seasons.

§ 142. In some of our domestic, and in several other animals, we observe small sacculated cavities formed by reflections of the skin in certain places, in the walls of which the sebaceous glands are more largely developed and much more active than in the surrounding portions of integument. Such are the lachrymal cavities, as they are called, under the eye of the deer, the cavities between the hoofs of the bisulcate ruminants generally and the small sebaceous sacs near the udder of the ewe, the umbilical sac of the common boar, the anal sacs of the carnivora, and the sacs which are found close to the glans clitoridis, especially in the Solidungula.

§ 143. The largest of all the sebaceous glands of the skin are encountered in the eyelids, between the marginal crescentic cartilages and the fibres of the orbicular muscle. These glands, which are universally designated by the epithet *Meibomian*, secrete a thin sebaceous matter, which is continually poured out upon the edges of the eyelids and around the roots of the eyelashes by the little openings which may be observed arranged in an even row behind the ciliæ. This thin unctuous fluid defends the edges of the eyelids from the moisture and acrimony of the tears, and also serves to prevent the escape of the tears at all times over the cheeks. The Meibomian glands are generally of a white colour; but they are of very different forms and sizes in different animals. In all essential particulars their structure is that of glands in general,—they are divided into glomeruli, and these again consist of pediculated primary vesicles. In *fig.* 158 may be found representations of two Meibomian glands from the fœtal calf of four months: numerous secreting vesicles *c* form acervuli or glomeruli, in the midst of which run the primary excretory ducts, which all terminate in the common duct *a*, that extends through the middle of the gland to open at *b* on the inner edge of the eyelid. In the horse the Meibomian glands are scarcely the length of small barley-corns. In man they extend over the greater part of the surface of the eyelid, and are readily seen, as among the mammalia generally, through the conjunctiva. As these glands open in the line of transition between the cuticle of the eyelid and the epithelium of the conjunctiva, they may be viewed as transition forms from the proper sebaceous to the proper mucous gland.

§ 144. *Sudoriparous Glands.*—These are among the number of recent anatomical discoveries. They have been particularly examined and described by Gurlt* in his investigations into the structure of the skin and its dependencies. The sweat glands may be said to be contained in the substance of the corium; for the most part, however, they project into the subcutaneous cellular tissue, or they are even situated in it entirely, so that the corium is only transpierced by their excretory ducts. It is probable, though not yet demonstrated, that the sweat, like the sebaceous, glands are developed by inflections of the epidermis. They are generally larger than the sebaceous glands, and consist either of a congeries of sacculi, so that they appear of an irregular mulberry form (*fig.* 43, *i*), which is their figure in man and the domestic mammalia generally, or they are simple sacs, which is the appearance they present

* "Magazin für die gesammte Thierheilkunde," Bd. i. S. 194, Taf. II. III.; und Müller's "Archiv." 1835.

in the ox and in the carnivora. Their contents being watery and uncoloured with pigmentary matter, they are highly transparent, and much more difficult to discover and to examine under the microscope than the sebaceous glands. Their excretory ducts, generally of extreme delicacy, and more frequently straight than sinuous or spirally twisted (*fig.* 43, *k*), either accompany the sebaceous ducts and open close to them on the surface, or they run and also terminate between these. The office of these glands, as their name implies, is to secrete the sweat. The insensible perspiration, however, is in all probability an exhalation of water and other volatile matters from the corium,—products of the blood which circulates in the peripheral capillaries covered only by the epidermis.*

Horny Tissues connected with the Epidermis.

§ 145. *Hair.*†—Hairs are epidermic threads implanted in the substance of the corium, or they are horny cylinders produced by involuted and

* There seems no occasion to deny the insensible perspiration as a product of the sudoriparous glands, as well as the sensible perspiration or sweat. The impermeability of the cuticle opposes an insurmountable obstacle to any escape of vapour from the surface, save through the pore of a sebaceous or sudoriparous gland. Something is indeed due to simple evaporation, but it has been estimated at no more than one-sixth part of the entire loss by the skin.—*G. G.*

† Gurlt und Hertwig, "Magazin für die gesammte Thierheilk." 1836. Heft. ii. S. 201; und Müller's "Archiv." für 1836. The hair-bulbs are described and figured by Gurlt in his excellent papers, as closed, and it is only in this particular that my observations differ from his.

revoluted processes of the epidermis. They stand in the same relation to the skin as the nails of man and the claws of animals, and, to a certain extent also, as the teeth to the gums that surround them.

When a piece of the hide of an animal covered with hair, such as that of the ox or horse, or the scalp of the human subject, which has lain for about forty hours in a solution of carbonate of potash, is divided perpendicularly, and in the direction of the hairs with a very sharp knife, we frequently succeed in cutting through one or more of the hair-bulbs exactly in the middle. To obtain the best view of this object, a moderate or medium power should be employed, and it may be viewed either as an opaque body by direct light, or, a delicate slice being removed with an appropriate double knife, it may be examined by transmitted light. When the hair of the bulb divided in this manner is young, the appearance obtained is that which is represented in *fig.* 42. The epidermis *b*, of the cutis *a*, *a*, is reflected funnel-wise at *c*′, and forms the particular excretory canals *d*, *d*, which unite in the common duct *c* of the sebaceous glands *n*, *o*, *p*, and also the sheath of the hair, penetrating for this end more deeply into the corium, and expanding at *e* in order to form the sheath of the hair-bulb; it then contracts at *f*, and being reflected at *g*, it again swells out and forms the proper capsule of the hair-bulb at *h*, receiving by the infundibuliform inlet below, the vessels *i*, and the nervous bundles *c*′ (*fig.* 94), which penetrate to the pulp *k*; the reflected epidermis then forms the shaft of the hair *l*, and this advancing clears the skin and appears externally at *m*. Should the root of the hair not be divided precisely in the line of its axis, or should the hair be old, then the appearances presented are those exhibited in *fig*. 43, where the bulb and the secreting pulp are seen to be closed. In this way each hair is found to be, in fact, a horny tube, an immediate process of the epidermis, including what may be called a medullary central thread, produced in the substance of the corium or in the subcutaneous cellular tissue. The hair-bulb itself is nothing more than the deepest, latest formed, soft, and therefore expanded portion of the shaft, which, as it advances, hardens and contracts to the diameter of the shaft. At *f*, *g*, where the sac suffers reflection outwards in order to constitute the bulb, circles of cells are formed which harden, and being pushed onwards by others of more recent formation, continue adhering to the hair to its extremity. In some animals the hair appears articulated, which is a consequence of the circle of cells *f*, *g*, being produced alternately of greater and smaller sizes; in other creatures the hair is secreted of different colours in different parts of its length, which is the effect of the ring of cells containing a larger or smaller proportion of colouring matter. The entrance to the medulla or pulp of the root, *f*, *f*, is wide in young hairs, and vessels and nerves of considerable size are seen entering, and forming terminal loops at *k*; but in old hairs, just as in old and fully formed teeth, the canal of access is very small, and in grey hairs it is almost completely closed.

The use of hair or fur is obvious: by entangling a large quantity of air it becomes one of the worst conductors of heat, and assists animals consequently to maintain their temperature at or near the proper standard. The elasticity of the hairy coat of animals makes it a defence to a certain extent against mechanical injuries; and its unctuousness enables it to resist some chemical agencies. The whiskers or strong hairs about the muzzles of certain animals, particularly the cat tribe, are also in some sort especial organs of touch, and on this account deserve particular notice.

§ 146. *Tactile Hairs.*—The stronger the hair the deeper does it penetrate the corium. The roots of the whiskers, or tactile and peculiarly sensitive hairs of mammalia, observed about the lips and round the eyes, lie completely under the skin, sunk amidst the cellular tissue, and sometimes even the subjacent muscles. The bulbs of these hairs are enclosed within a strong, highly vascular fibrous covering which is identical in its structure with the tactile sacs of the hog's snout (§ 140), being surrounded by a hollow nervous bundle which forms a circle of closed terminal loops immediately under the epidermis about the orifice of the sheath for the hair. Into the central pulp of these great hairs we also observe an abundance of nerves surrounded by blood-vessels entering, the terminal loopings of which, in all probability, are the same as those observed in the roots of the large bristles of the hog.*

* The peripheral distribution of the cutaneous nerves is best observed by achromatic glasses in the skin of the hog after it has been boiled and laid in oil of turpentine. An injection of the vessels with levigated cinnabar or white lead suspended in

§ 147. *Wool.*—Wool is a kind of hair familiarly known, which differs from the ordinary hairs of such animals as the horse, ox, dog, &c. in its greater length, and in being crisped or curled in various degrees. Wool also differs from the hairs of the animals mentioned in being not cylindrical like them but irregularly flat.* The hairy coats which are characterised as *fur* are also modifications of the same structure which it is sufficient to mention.

§ 148. *Bristles.*—These, too, are but stronger hairs. The bristles of the hog grow together in threes, in more or less completely closed cavities filled with fat cells (*figs.* 71, 72, *and fig.* 94). The outer ends of hogs' bristles are generally seen split into two or three. The extremities of hairs are usually simple and solid.†

Horny Defences.

§ 149. The extreme parts of man and the mammalia are terminated and protected more or less completely by nails, hoofs, &c. These defences are principally developed in the course of the second

oil of turpentine, brings these into view. The primary nervous fibres accompany the terminal loopings of the capillary vessels. The double knife is of essential service here. This instrument consists of two lancet blades, the edges of which can be approximated in various degrees and fastened whilst sections are made.

* Some interesting illustrations of the structure of hair and wool are given in Martin's "Natural History of Quadrupeds," p. 156, from observations made by Mr. Youet.—*G. G.*

† The work of Eble, "Die Lebre Von den Haaren," 2 Bde., Wien, 1831, is extremely full upon all matters connected with the hair.

half of the intrauterine life. They consist, in the first instance, of a congeries of polyhedral nucleated cells without intercellular matter (*fig.* 226), and are soft and yielding. At the period of birth, indeed, they are still soft and fibrous; but they soon harden when exposed to the air, the nuclei and nucleoli of the horny cells disappearing at the same time (*fig.* 34). When these horny tissues are coloured, pigmentary cells in variable numbers but disposed with a certain degree of regularity, are always readily discovered. During the fœtal period these pigmentary cells are seen to be provided with nuclei and nucleoli; in the horny parts of older animals, though the pigmentary cells are still readily enough demonstrated and sharply defined, they are without nuclei (*fig.* 35, *b*, *b*; *fig.* 38, *d*, *d*). The nails of man, the claws of carnivorous animals, and the hoofs of the pachydermata, ruminantia, and solidungula, serve as means of defence against mechanical injury, and in many cases as weapons of offence. They may be viewed in every case as a multilamellar, peculiarly hard epidermis, furnished with a core,—a highly vascular and sensitive portion of the corium very commonly stretched over some terminal bone. The only exception to this is in the appendages called *corns* in the horse, which include no bone or bony process.

Implanted, Flat Horny Structures.

§ 150. *Nails of Man.*—The nails lie with their canalicular hollowed out surfaces upon the vaulted dorsums of the last articulations of the toes and fingers, and are attached by means of mutually penetrating ridges of the horny structure and the corium. The posterior and wedge-like ends or roots of the nails are inclosed between duplicatures of the corium about two lines in depth; and it is in this situation that we observe numerous filiform papillæ sunk in the edge of the root, precisely in the same manner as single papillæ are seen to penetrate the roots of the several hairs. These papillæ are the sources of growth of the nails, just as the papillæ are the sources of growth of the hair. This accordance in structure between nails and hair is further manifest upon the convex aspect of a nail, with this difference however, that as there is no sebaceous matter poured out into the sheath of the nail, the sheath often remains adherent to the surface of the nail. As it is obvious that the longitudinally disposed connecting ridges of the corium remain stationary, whilst those upon the corresponding surface of the nail are in a perpetual state of progression, it would be difficult to conceive how the connexion between the nail and corium could be maintained, were it not that the entire living surface in contact with the nail was a secreting matrix and perpetually elaborating horny cells, which are added to those prepared by the papillæ at the root of the nail, and so strengthen it continually from the root onwards to the point where it becomes free.

§ 151. The nail in the human fœtus, whilst yet soft and in the first period of its evolution, consists of nucleated cells, the youngest of which lie at every point of contact upon the corium. Even in adults young cells are always to be discovered at the edge of the root, which become horny outwards in successive layers.

§ 152. *Claws of the Carnivora.*—These only differ from the nails of man and the quadrumanous mammals in this, that they almost entirely surround the last digital phalanges, being completed on the plantar aspects by a longitudinal streak of cuticle. These claws are either colourless or coloured. When they are coloured, many fine pigmentary cells are observed forming streaks in the anterior vaulted portions, precisely as in hoofs that are streaked (*fig.* 35, *b*, *b*). The root of the claw in the dog is surrounded by a projecting edge of the nail-supporting digital phalanx. The same segments of the paw in the cat, tiger, lion, &c., are drawn so much backwards and upwards that in ordinary progression the points of the claws do not come into contact with the ground, an arrangement by which they are never blunted, and so made useless as instruments of prehension, when at the will of the animal they are brought into play. In the dog, where there is no arrangement of this kind, the claws are always found blunted and worn away. The use of the claws as means of defence and of offence is obvious.

Horny Capsules.

§ 153. *Hoofs of the Ruminants.*—These are greatly strengthened but still immediate continuations of the cuticle as it passes over the last digital phalanges of the extremities. The particular parts of the hoof of an ox, sheep, or deer enumerated are, 1st, the *crust* or *wall*, which, as the part corresponding to the nail or claw, surrounds the anterior and lateral aspects of the last phalanx; and 2d, the *sole*, which protects the plantar aspect of the same bone. The soft parts that lie between the bony digit and the hoof are, as in the human subject, a continuation of the corium, with the hoof for its cuticle. The hoof and this portion of the corium are in most intimate connexion, the fusion being effected by the same arrangement of parts as that which we have already seen to exist between the nail and the piece of integument that supports it in the human subject. The softer fleshy parts lying between the bone and the hoof are to be regarded as a continuation of the corium with the horny hoof for its cuticle. Where the hoof lies perpendicularly upon or over the corium the union takes place by the mutual reception of perpendicularly arranged horny plates from the hoof and of fleshy lamellæ from the corium. But in situations where the hoof is the substratum and supports the soft parts, the connexion is of a different kind, and takes place by means of numerous fusiform papillæ containing an abundance of vessels and nerves, and received into funnel-shaped pits of the interior or upper aspect of the hoof. This mode of connexion is observed at every part where the growth of the hoof is most active,—the growth taking place as usual by the evolution of new cells from the surface of the matrix; it consequently obtains all around the upper edge of the hoof, which as corresponding in the form and arrangement of its parts to the root of the human nail, may be spoken of as the root of the hoof.* The place where the horny wall of the hoof begins is indicated externally by a slightly raised line, along which there is a sudden and marked increase of the production of the horny epidermic cells. The wall of the hoof is pierced from the crown to the bearing edge by many fine canals, and when coloured it is marked by pigmentary striæ. The canals belong to the sebaceous follicles; the coloured striæ are due to intermingled pigmentary cells.

§ 154. *Hoofs of the Hog.*—The true hoofs of the hog are formed of fine compact horn; they are the same in all respects as those of the ruminant. The false hoofs of the hog are less completely developed, and, in point of structure, hold a middle place between the true and the false hoofs of ruminants. In the walls of the true hoof especially we observe papillæ running diagonally downwards and outwards from the upper edge, and continuous with corresponding delicate tubuli which end on the outer surface of the wall.

§ 155. *Hoof of the Horse.*—The hoof of the solidungule presents us with the structure and peculiarities of the horny casings in the highest perfection.†

* The arrangement of parts is seen in the representation of the hoof of the horse, *fig.* 36, *b;* and in the nail of man, *fig.* 40, *c*, *d*.

† To examine the structure of the horny tissue microscopically, it is essential to be provided with fine laminæ cut in different directions and from different parts of the structure to be investigated. The black-brown or streaked hoof of a horse, for instance, should be cut perpendicularly through with a fine saw, and then slices taken from different parts,—perpendicularly, transversely, slanting in various directions, &c. The surface of

In a section cut perpendicularly from the posterior wall (*fig.* 36), we observe on the crown edge *a* the conical and spindle-shaped papillæ *b*, continued onwards as fine canals, and between these, excretory ducts of glands, which enlarge opposite the places where the papillæ contract to a point, and then turn spirally round like the ducts of the sebaceous glands, becoming narrower in their course through the horny parietes, where the spiral turns are also less regular.

In the anterior or digital wall of the hoof the papillæ pass over into horny infundibula and canals, which are at the same time the ducts of the sebaceous glands. These filiform and twisted canals are rather finer than human hairs; they run parallel to one another downwards through the wall (*fig.* 37, *a*), and open on the inferior or bearing edge of the same part, as the section represented in *fig.* 38 shews.* The canals contain sebaceous matter, which in black hoofs is of a brownish-black colour, and, therefore, contains numerous pigmentary granules. Other parts of the hoof contain precisely similar canals. The horn of the sole and frog of the hoof is soft and elastic in a very high degree.

these slices having been made smooth with a file are to be glued to a strong board, and, when firm, reduced by planing. The larger and cleaner shavings from each section are to be collected separately, and the planing continued till the pieces are reduced sufficiently. These are then to be detached by means of warm water, dried, and having been dipped in oil of turpentine, are fit for examination. The shavings are to be treated in the same way.

* Vide Explanation of the Plates, *figs.* 36–39.

The substance of the hard masses called *corns*, which are seen on the inner aspects of the legs under the carpus in the fore legs, and under the ankle joint or tarsus of the hind legs in the horse, is also soft in its texture. It bears the same relation to the corium as the sole of the hoof does to the portion of integument which it protects.

§156. *Horns of the Ox, Sheep, &c.*—These horny capsules have very much the same structure as the walls of the hoof in the same class of animals, as also in the pachydermata and solidungula. The conical process of the frontal bone which supports the horn (the core of the horn) is somewhat rough on the surface, and is marked by numerous more or less longitudinal furrows in which run the vessels of the superimposed layer of corium, just as we observe them in the coffin bones of the horse or ox. At the root of the horn the cuticle is greatly strengthened, precisely as it is along the crown edge of the hoof, and from this circle onwards the horn is continually receiving accessions of new horn-cells in the way we have already seen to pass, when speaking of the growth of nails, claws, and hoofs, these cells being produced at every point upon the surface of the soft parts covering the core, and the horn being gradually pushed on by their accumulation from the base towards the point. The bony core is not generally more than about two-thirds of the length of the horn; but from the point of the core certain vessels proceed which run through the axis of the solid part of the horn, and only terminate at its extremity. The walls of the hollow portion of the horn consist of concentric and severally including laminæ, with longitudinally disposed ridges and intervening furrows, so that on the surface of a transverse section the horny laminæ present themselves as concentric sinuous lines. Immediately upon the corium of the core newly formed horn-cells are found in abundance, which in dark-coloured horn are intermixed with the pigmentary matter of the Malpighian or mucous body. Delicate sections of compact horn exhibit the elementary layers (*fig.* 34, A), which in fibrous horn are lineally arranged, and more firmly connected lengthwise than laterally (B). In the longitudinal section of the massive point of a horn the central vessels or canals are observed in the axis or middle (*fig.* 35, *c*, *c*), and in streaked horn, angular and polyhedral corneous pigmentary cells arranged in longitudinal lines, exactly as in streaked nails, claws, and hoofs (*b*, *b*, *b*). The sebaceous glands of horns are still less known than those of hoofs; it is very seldom, indeed, that we discover a trace of their excretory ducts, which as well as the glands must nevertheless exist, as sebaceous matter is a kind of necessary adjunct to the epidermic tissue in all its modifications.

COVERINGS OF THE INTERNAL SURFACES OF THE BODY—EPITHELIA.

§ 157. Recent investigations have shewn that not the skin only but all the naturally free surfaces of the human and animal body are covered with cuticles which, in the interior of the body, are called epithelia. The epithelia are always in contact with fluids, and are, therefore, of a soft and pliant nature; the nuclei of their cells do not disappear like those of the cells of horn. Like the epidermis, the epithelia are engendered on the free surfaces of internal membranes by a regular exudation of cells, which compose them in their continuity, and scale off in quantities proportioned to the amount of external influence to which they are exposed, in a greater measure, consequently, from the mucous than from the serous membranes, from the mouth and intestinal canal than from the air-passages and the ducts of glands.

The forms presented by the epithelial cells are very various. In the *tessellate* or *pavimented epithelia*, the cells are simple, lenticular, and attached by their flat sides. In the *cylindrate epithelia*, they are campanular, cylindrical, or in the form of short cell-fibres, and are either sessile or pediculated in their attachment. The free surface of the outermost cells is in some parts covered with delicate movable processes (ciliæ), and the epithelia so furnished are entitled *ciliate epithelia.*

§ 158. *Tessellate Epithelium.*—This form of epithelium covers all the more delicate membranes of the internal surfaces of the body, viz. the finer mucous membranes that are without special glands, and the serous and synovial membranes. It is composed of lenticular cells, which are generally embedded in an intercellular substance, contain nucleolated nuclei in their interior, and form either a simple cellular membrane, or a membrane of but a few layers of cells. This form of epithelium seems to exfoliate rarely.

§ 159. *Tessellate Epithelium of Serous Surfaces: (a). Of the Lymphatic and Sanguiferous Systems.*—The larger blood and lymphatic vessels consist of a number of concentric laminæ of divers formation severally enclosing one another. The outermost layers consist of cellular tissue; the second or middle, of fibres or fibrils which confer on the vessels their passive or active contractility,—these are elastic tissue, contractile and muscular fibres; the third, or innermost layer, is a serous membrane which extends into the most minute ramifications of the vessels, and can even be demonstrated in the capillaries; it is covered with a delicate tessellated epithelium which, although it is probably never absent, is nevertheless but rarely visible in the capillaries. The epithelium of the vascular system is more especially easy of demonstration on the walls of the cavities of the heart and of the great vascular trunks, particularly of the venous system; it is not so readily shewn in the arteries and absorbents; in the capillaries it is, as just stated, of the greatest delicacy, and seldom recognisable. If the lenticular cells of this epithelium do not obviously inclose nucleolated nuclei,* as those of tessellated epithelia in general do, then must we view it as a cytoblast membrane, and not assent to Vogel's† proposition, that the pus-globules alone are neither more nor less than altered

* The appearance of tessellated epithelium is given as seen under a low power in *fig.* 47, under a higher power in *fig.* 226, and the individual cells are represented in *fig.* 193, *a.*

† "Untersuchungen über Eiter und Eiterung," &c.

epithelial cells, but presume the same of the lymph and blood-corpuscles themselves; and this the rather from the epithelial cells of the vascular parietes being often scarcely larger than the blood-globules. In every case the detached cells of the vascular epithelium when mingled with blood-globules can only be distinguished from them with great difficulty and with particular attention, the marks of distinction being especially their paler colour and the nucleoli which they contain.

§ 160. (*b.*) *Tessellate Epithelium of the Serous and Synovial Sacs.*—All the serous membranes of the internal cavities, the inner membranes of the lymphatics and blood-vessels inclusive, are provided with a tessellated epithelium, which only differs from that of the lining membrane of the heart and great vessels in having the cells of rather larger size. This is the form of epithelium that covers, 1st, the pleuræ,—the pleura costalis, and the pleura pulmonalis; 2d, the pericardium, both where it forms the bag that encloses the heart, and in its reflection over the surface of this organ by which it forms its external envelope; 3d, the peritoneum—*abdominale et viscerale;* 4th, the tunica vaginalis testis, both as it includes and covers the testis; 5th, both aspects of the tunica arachnoidea of the brain and spinal cord; 6th, the inner serous lamina of the dura mater of the brain and cord; 7th, the outer surface of the pia mater with the exception of so much of it as lines the ventricles of the brain, which is furnished with a ciliary tessellated epithelium; 8th, the membranes of the ovum (*fig.* 103.)

§ 161. *Tessellate Epithelium of Mucous Mem-*

branes.—Every form of epithelium is encountered covering the mucous membranes. A tessellate epithelium covers the mucous membrane of the cavity of the tympanum and of the cells of the pars petrosa of the temporal bone, the mouth (*fig.* 220), and partially the fauces, the œsophagus, the stomach save where the œsophagus enters, the vesiculæ seminales, the pelvis of the kidney (on this last as well as on the urinary bladder passing over into the cylinder epithelium); further, the nymphæ, clitoris, vagina and its parts as high as the middle of the neck of the uterus; the inner aspect of the sclerotic and cornea, and the outer aspect of the choroid of the eye; still further, the most delicate secreting canals and vesicles,—the finest excretory ducts of the salivary glands, of the liver, of the larger mucous glands, and of the tubuli uriniferi. All the points of transition of the skin into mucous membrane possess a covering analogous to the tessellated epithelium; for example, the lips, the outer aspect of the membrana tympani, and even the surface of the meatus auditorius externus, the entrance into the nostrils, the margins of the eyelids, the external orifice of the male urethra, and of the female pudenda generally.

Upon the synovial membranes the tessellated epithelium forms several layers. The clear spines described by Valentin,* as occurring in the angles of the cells of the choroid plexus, are the ciliæ of its ciliate epithelial cells (*fig.* 221 and 222, *c*). The tessellate epithelium not unfrequently passes over into a couched fibro-cellular epithelium (*fig.*

* Nov. Acad. Nat. Curios. p. 45, tab. iv. fig. 24.

102, *c*), for instance on synovial membranes and vessels; it also sometimes encloses capsule-like papillæ, for example, in the tongue.

§ 162. *Ciliary Tessellate Epithelium.*—The tessellated epithelium which covers the delicate pia mater that lines the cerebral cavities, not even excepting the infundibulum, the aqueduct of Sylvius, and the cavity of the olfactory nerve, supports an abundance of very active ciliæ,* which are attached along the edges of the epithelial cells to little warty-looking elevations (*fig.* 221 and 222). Examined in front, the cells appear in the guise of B, *fig.* 48. The ciliæ are filiform, and move in the manner of the lash of a whip. The cylinder ciliate epithelium of the air-passages acquires the form of the tessellated ciliate epithelium in the finer subdivisions of the bronchi.

In the primary tubuli of nerves an active ciliary motion is conspicuous prior to the coagulation of their contents; the motion seems to be produced by short conical ciliæ† (*fig.* 88, 4, *a*, and 5). Should the interior of the nervous tubuli be really found to exhibit the ciliary phenomena, which have been suspected there, a ciliary tessellate epithelium will in all probability be discovered as their cause; for ciliary organs have not yet been found connected with any other structure than an epithelium.‡

* Discovered by Purkinje, Müller's "Archiv." 1836. S. 289.

† It is only with the best glasses and lamp-light that these ciliæ are visible, a fact of which I have often satisfied myself in company with Professor Valentin, who first described them.

‡ The contents of the nervous tubuli are obviously as fluid as the blood during life. Vide what is further said of the structure of nerve, § 262 *et sequent.*

The ciliæ are in general, as upon the cylinder ciliate epithelium, directed towards the natural outlets of the cavities or canals they occupy, and, therefore, move the fluids with which they are in contact in this direction.*

§ 163. *Cylinder Epithelium.*—As the lenticular cells of the tessellate epithelium lie in the plane of the general epithelial surface, so do we find the elongated epithelial cylinders of the cylinder epithelium placed perpendicularly upon the plane they cover; cylinder epithelia, indeed, are very commonly attached either immediately or by the medium of a style, to a simple tessellate epithelium, from which the elongated cells seem to grow much in the same way as grain does from the ground (*fig.* 46, *b*, *c*, in section).

The form of the individual epithelial cylinders is very various, and this apparently according as they contain one or more nuclei lying one over another, or according to the number of cells of which they consist, and the length of these severally. When the tessellate epithelium is passing over into the cylinder form, the cells first stand more raised, or in the guise of hemispheres, from the surface; then they rise still higher, and present themselves as semiellipsoids; farther on, the base of the cell appears constricted, and the ovoid or amygdaloid epithelial body begins to be pediculated; the style grows thinner and longer, and the corpuscle

* An historical account of the discovery of the ciliæ, as well as many original observations, will be found in the admirable article by Professor Sharpey, "Cyclopædia of Anatomy and Physiology," vol. i. p. 606.—*G. G.*

becomes campanulate, and then cup-shaped. These transitions may be followed almost without a break upon the conjunctiva of the inner aspects of the eyelids (*figs.* 47 and 48); in the intestinal canal, and in the stomach at the cardiac orifice; in the larger ducts of the salivary glands; in the ductus choledochus communis; in the prostate, Cowper's glands, vesiculæ seminales, vas deferens, and tubuli semeniferi, and in the urethra. The many-celled epithelial cylinders grow as the single-celled do from a level tessellate epithelium: after one cell has acquired the cup-shape, the subjacent lenticular tessellate cell begins to rise, being connected with the incident one by means of the common style, it is then pinched off from the newly formed tessellate cell and becomes fusiform; the cell just formed undergoes the same process, and so on, until the compound corpuscle finally contains two, three, four, and it may be, five nuclei, and is thus produced into a kind of free cellular fibre (*figs.* 223 and 224). Cylinder epithelia, so far as I am aware, are only met with upon mucous membranes; the multicellular present themselves particularly in the nostrils, in the trachea, in the uterus, in the gall-bladder (*fig.* 24), and fully developed in particular parts only of the intestinal canal.

§ 164. *Ciliated Cylinder Epithelium.* — The crown of the cup-shaped and many-celled epithelial cylinder of several of the mucous membranes is covered with ciliæ (*fig.* 48, A, *figs.* 223 and 224), which are broader and blunter at the point than those of the ciliary tessellated epithelia. Cylinder epithelia with ciliæ are found in the nasal cavities, frontal sinuses, maxillary antra, lachrymal ducts and sac, the inner angle of the conjunctiva, the posterior surface of the pendulous velum of the palate and fauces, of the Eustachian tube, the larynx, the trachea and bronchi, to the finest divisions of these last, on the inner portions of the vagina, the uterus, and the Fallopian tubes.

In the middle of the crown or circlet of ciliæ, the globular outer nucleus of the epithelial corpuscle is observed. This nucleus projects like an hemisphere, and, under the compressor, or betwixt two glass plates, but also when no force has been used, frequently escapes from its nidus, and is then found at liberty (*fig.* 48, C, C, A and B, *e*).

In the ciliary cylinder, as in the ciliary tessellated epithelium, the motions of the ciliæ are directed towards the natural openings of the cavities or canals they cover: in the uterus, for instance, towards the os uteri; in the larynx, towards the rima glottidis, &c.; by this means the investing mucus is carried onwards, and finally expelled. The motions of the ciliæ seem to depend on minute, but very indistinctly visible muscles, which lie under the ciliary elevations of the crown of the corpuscle to which they are connected by one extremity. A surface covered with ciliæ in active operation, when viewed obliquely or in perspective, generally presents the appearance of a field of corn waving with the wind. The motions of the ciliæ severally are hook-like, whip-like, &c. The ciliary motion and the ciliæ were first seen and described by Purkinje and Valentin* in man and the mammalia.

§ 165. Ciliary motions are far more general among the invertebrate than among the vertebrate series of animals. The invertebrata that live in water have even very commonly ciliæ on certain portions of their external surface; and in the infusoria these delicate processes serve as means of locomotion; in the pediculated vorticella (*fig.* 87), which presents so striking a resemblance to the bell-shaped and cup-shaped ciliary corpuscles, they serve as means of attracting nutriment. The creature establishes circular currents in its vicinity by means of its ciliæ, and so brings organic molecules or small infusoria within its reach, when it suddenly retracts the body upon the now spirally twisted pedicle and closes the campanular orifice (C). This motion of retraction, as I conceive, depends on the composition of the pedicle, which consists of a vessel, which the creature has the power of injecting with fluid, and so of erecting or straightening, and of a fine contractile bundle wound spirally about the vessel, by the contraction of which the vessel

* Müller's "Archiv." 1834, S. 391; also in the tract entitled, "De Phœnomeno generali et fundamentali," &c. Vratislaviæ, 1835; and in a paper, "Ueber die Unabhängigkeit der Flimmer-bewegungen der Wirbelthiere von der Integritaet des centralen Nerven-Systems," in Müller's "Archiv." 1835. The subject was still further pursued by Henle in his Inaug. Diss. "Symbolæ ad Anatomiam Villorum Intestinalium, imprimis eorum Epithelii," &c. Berl. 1837; and "Ueber die Ansbreitung des Epitheliums in mensch. Koerper," in Müller's "Archiv." 1838.

is emptied and the retraction effected.* In this structure we have an instance of an apparatus of locomotion of the simplest kind,—the effect following the antagonism of a single erectile canal and a single contractile bundle.

Inversions or Invaginations of the Epithelium—Epithelial Glands.

§ 166. The mucous membranes being but productions of the general external integument over the open cavities of the body, and agreeing with the skin in structure in all essential respects, we might *a priori* have expected to find *epithelial glands,* or glands connected with the coverings of mucous membranes, just as we had found *epidermal glands*—sudoriparous and sebaceous glands—connected with the skin. And this we do in fact; the mucous membranes are plentifully supplied with involutions of the epithelium endowed with the secreting faculty, and denominated mucus-glands in virtue of their office, which is to secrete the slimy fluid with which the mucous membranes are bedewed. They are commonly divided into mucous crypts, which are simple sacs, and mucous glands, which are constituted by a cluster of such crypts terminating in a common canal.

The epithelium of the mucous membranes is

* Looking at the representation of this creature in Ehrenberg's masterly work, "Die Infusions-Thierchen als Vollkommne Organismen," fol. Leipz, 1838, I conclude that either I am wrong in the views above stated, or that Ehrenberg has overlooked the purpose of the spiral bundle.

also to be understood as covering all the processes which these send off in the shape of ducts to glands of a larger size, and secreting peculiar and divers fluids — the liver, pancreas, &c. &c. As these canalicular processes, however, are formed by the mucous membrane at large, and not merely by its epithelial indusium, they will not be spoken of here, but under the head of the apparatus to which they are subordinate — the glands.

§ 167. *Mucous Follicles.*—These are vesicular, more or less completely pediculated, simple involutions of the epithelium into the subjacent corium. They are met with in all the mucous membranes which are habitually covered with a proper thick slime; they are wanting, on the contrary, in those that are merely moistened with a watery or very thin fluid, such as the frontal and maxillary sinuses, the cavity of the tympanum, &c. These follicles secrete the mucus-corpuscles (*fig.* 25, B), which, mingled with serous fluid and detached epithelial cells or cylinders compose mucus. It is very necessary not to confound with these mucous follicles the larger involutions of the entire mucous membrane, and into which mucous follicles and mucous glands, or simple and multilocular inversions of the epithelium, pour their products.

§ 168. *Mucous Glands.* — These in point of structure and general appearance are almost identical with the sebaceous glands of the skin. They lie deeper in the mucous membrane than the follicles, and frequently extend beyond this into the submucous cellular tissue. They consist of agglomerated glandular vesicles, which form botryoidal masses, whereof two commonly lie near one another, and unite their several excretory ducts into one common to both, which then opens upon the surface.* Their office, like that of the follicles, is to secrete the mucus which, poured out upon the surface of the mucous membranes, lubicrates and defends them, aiding the transmission of the chyme and fæces through the alimentary tract, protecting the nose, the windpipe, and the bronchi from dust, &c.

§ 169. With a view to assigning to the epithelial glands their place in a natural arrangement of the glandular system, the following brief sketch of a division of its various elements is here subjoined:—

Those organs only are to be regarded as true or secreting glands, which from the general circulating fluid separate a peculiar fluid, a process which is accomplished by one or more pediculated vessels or elongated canals, the separated fluid being mostly received into excretory ducts which terminate upon the external surface of the body or on the surface of a mucous membrane. They are conveniently divided into 1st, Cutaneous Glands—inversions of the corium and of the mucous membranes; and, 2d. Cuticular Glands—inversions of the cuticle into or through the corium. The cutaneous glands again divide themselves into (*a*) glands of the skin, and (*b*) glands of the mucous membranes; and the cuticular glands into (*a*) glands of the epidermis—epidermic glands, and (*b*) glands of the epithelium—epithelial glands.

* Gurlt, vergleichende Physiologie, Taf. iii. *fig.* 11, *a.*

The following table gives a synoptical view of the entire glandular system.

GLANDS.	Secreting glands.	Cuticular glands.	Epidermal glands.	Sudoriparous glands.
				Sebaceous glands.
			Epithelial glands.	Mucous follicles.
				Mucous glands.
		Cutaneous glands.	Glands of the Corium.	Milk glands.
			Glands of the mucous membranes.	Lachrymal glands.
				Glands of Harder.
				Salivary glands.
				—— Parotid.
				—— Submaxillary.
				—— Sublingual.
				Pancreas.
				Liver.
				Kidneys.
				Prostate.
				Cowper's glands.
				Testes and Ovaria.
				Lungs.
	Vascular glands .		Blood glands.	Thyroid.
				Thymus.
				Suprarenal capsules.
				Spleen.
			Lymph glands.	Lymphatic glands.
				Chyle glands.
	Doubtful glands			Pituitary body.
				Pineal body.
				Pacchionian bodies.

CARTILAGE.

§ 170. The cartilages are substances admirably calculated to fulfil various mechanical purposes in the economy, and frequently employed for these. They are found of different forms in different parts of the body. They are elastic in the highest degree, of a white colour with a bluish or yellowish tinge, very slightly transparent, and easily cut with a knife. Dried they are of a yellow or brown colour, transparent, and hard. On their free surfaces, when they enter into the composition of joints, they are covered with a delicate fibrous membrane — the synovial membrane. Cartilages contain but few blood-vessels and nerves.

Cartilages are divided into *permanent* and *ossific:* the former, as their name implies, persist as cartilages to the time of old age; the latter at a shorter or longer date are converted into bone. Examined microscopically, they present three kinds of intimate structure. 1st. In one we observe cells, or cartilage-corpuscles as they are called, scattered through a hyaline or intercellular substance,—*cellular cartilage* (*figs.* 53, B, 57, 58, and 217). 2d. In another, the cells or cartilage-corpuscles instead of being dispersed through a vitreous matter are scattered betwixt the meshes of a reticulated fibrous matter,—*reticular cartilage* (*fig.* 59). 3d. In a third, the texture is a mixture of the reticular and simply fascicular, the intersection of fibres being here very great, the fibres then running more in the manner of those which make up the elastic tissues,—*fibrous cartilage* (*fig.* 53 A). The bone-cartilage is that which forms the ground-work of the bones, and as such may be exhibited in the adult by removing the bony matter by means of a dilute acid; bone-cartilage presents the structure of bone, save that the rays of the bone-cells have disappeared (*fig.* 70, *b*).

§ 171. In none of the structures of animal bodies do we observe a greater affinity to those of vegetables than in cartilage. In fact, the form and grouping, and even the mode of origin, of the cells, are the same in cartilage as in plants.

The chorda dorsalis and the cartilage of the gill-rays of bony fishes, the gill-cartilages of tadpoles, &c. exhibit in different places and according to the degree of their developement, cartilage cells in different circumstances, precisely as we see them in a growing plant.* From my own observations, I am led to state that the cartilages of the mammalia which are destined to become ossified, present precisely the same appearances; according to the part of the cartilage from whence the specimen for examination is taken, and the cartilage itself, when several are examined at the same time, the appearances observed are very different, inasmuch as a particular cartilaginising process takes place as a preparation for the ossific process that is to ensue. The permanent cartilages, however, are evolved by a more simple process, and they are also maintained in their status when fully formed in a more uniform manner, and always with the appearance of cellular cartilage (*fig.* 57). The cartilage cells, discovered by Purkinje, lie by so much the more closely together as the cartilage is of more recent formation.

§ 172. *Permanent Cellular Cartilage.*—The embryo in the earliest period consists of an apparently uniform granular aggregation of cytoblasts, which,

* Schwann, "Mik. Unters." S. 17. Taf. i.

sooner or later, but in all parts of the body, and as a preliminary to the formation of the organic parts, produce or become changed into nucleated cells. From such an embryonic cell-mass the cartilages are produced. At first intercellular matter is only to be seen where the rounded corners of the imperfectly polyhedral cells leave little spaces between them. In the persistent cellular cartilages the intercellular substance increases simultaneously with, and even in a greater degree than, the cells by which the young cartilage augments in bulk, and also becomes firmer, acquiring ever more and more its appropriate outward form. The cells being pushed farther apart by the notable growth of the intercellular substance, they at the same time become slightly flattened, and often assume an elliptical or notched lenticular shape, something like that of a broad bean. The capsule of the cell is at this time no longer to be distinguished from the intercellular substance, which is now spoken of as *hyaline* or *vitreous cartilage;* and the fully formed cartilage cells, which are now called *cartilage corpuscles*, form spaces in the vitreous mass filled with a softer substance, amidst which the nuclei seem oftener to lie unconnected than to be attached to the bounding parietes. The cellular cartilage thus formed always exhibits upon the surface of a section different forms of the flattened cells which have been divided (*fig.* 217). The cells are always found more and more depressed and flattened in the circumference or bounding surface of the cartilage, as in the transversely divided septum narium, *fig.* 53, B, *b*. In the permanent cartilages of old animals, as in the septum narium represented in *fig.* 57, the nucleus, as a general rule, is granular in its structure.

In situations where the cartilage is relatively more expanded in order to acquire its full form and growth, the following circumstances may be observed:—

1st. In the cells, besides the primary cytoblast, another new one arises (*fig.* 217, *b*), which is evolved into a parent cell (*fig.* 217, *f*), the envelope of which coalesces through a great part of its circumference with the walls of the parent cell. The part of the envelope of the young cell which is free becomes thickened, and changes into the flat septum, which effects a greater isolation of the now dissevered cells. In this way we often see from three to four cells, of the most recent formation, separated by a bar or cross piece of hyaline substance,* and of these only one, perhaps not one, is a parent cell.

2d. Cytoblasts (cell-nuclei) and cells arise in the hyaline substance, and then grow till they attain the size of the primary and neighbouring ones.

3d. New cells are formed on the periphery, by which the cartilage comes to be augmented by external apposition of parts.

Among the permanent cellular cartilages we

* An indication that the intercellular or hyaline substance of cartilage is formed and increases from the absorbed cytoblastema, the mode of growth being by thickening of the cell-walls, probably in consequence of a setting or coagulation of the hyaline substance upon the inner aspects of the cells during their developement.

find the cartilaginous septum narium, and the cartilages of the alæ and point of the nose; the semilunar cartilages of the eyelids; the cartilage of the external ear and Eustachian tube; the cartilages of the os hyoides and larynx, with the exception of that of the epiglottis, and the cartilages of the trachea and its branches; farther, the articular cartilages—those cartilages that cover the articular surfaces of the bones; the cartilage which terminates the base of the scapula; the cartilages of the ribs in man; and the ensiform cartilage of the sternum. The permanent cellular cartilages contain less soluble matter than the cartilages of the bones. Those of the fœtus are attacked with great difficulty by boiling water, and do not yield proper gelatine.*

§ 173. *Ossific Cellular Cartilages.*—All the bones of the body have cartilaginous rudiments; it is only during the process of ossification that the calcareous salts, which finally give them their characters, are deposited. We shall have more to say of these cartilages when we come to speak of the bones.†

* J. Müller* was the first who called attention to the different qualities of gelatine as procured from different sources,—a discovery which has led to the distinction of the old proximate principle called *Gelatine* into two principles designated *Chondrin* and *Glutin:* chondrin being the product by long boiling of all the permanent cartilages; glutin of the animal basis of bone, of ligament, cellular tissue, &c.—*G. G.*

† Ossification often begins in a soft membranous basis. In certain flat bones, as the parietal, nothing like cartilage is to be seen at any step of their growth; and the shafts of the long

* Poggendorff's "Annalen," B. xxxviii. S. 295.

§ 174. *Reticular Cartilage.*—In the cellular mass destined to the formation of reticular cartilage, so soon as an isolating intercellular substance is visible, we observe new cells evolved in the primary or parent cells, and between these new cells a new hyaline substance, the primary intercellular substance being simultaneously transformed into an elastic intercellular rete, in the meshes of which lie imbedded completely formed cells and others of more recent formation, and mingled with these older and younger nuclei (*fig.* 59). This variety of cartilage passes in some parts into a highly elastic and extensible reticulation: for example, at the root of the concha auris and of the epiglottis, in which scarcely any trace of cartilage corpuscles remains. Towards the extremity of the cartilage of the concha, again, the network disappears by degrees, and the structure passes over into cellular cartilage. The reticular cartilages do not afford gelatine any more than the cellular cartilages. In old age, we almost invariably meet with partial ossific deposits in cellular cartilage; these, however, are very rarely seen in fibrous cartilage, and probably never in reticular cartilage.

bones never appear cartilaginous before ossification, like the epiphyses. If it be said, that the membranous matter in question is merely a soft rudimental cartilage, it might as well be asserted, that granulations or clots of lymph are identical with any tissue which they may be destined to produce. In short, the soft tissue in which the osseous deposit may first be detected in certain flat bones and in the shafts of the long bones, cannot be regarded as identical with the well-known dense cartilage in which ossification begins in the epiphyses and in several flat bones.—*G. G.*

§ 175. *Fibrous Cartilage.*—The true fibrous cartilages are very tough, fibrous, and extensible. They consist of highly elastic parallel filaments, and are, therefore, very different in their structure from the reticular and cellular cartilages; in fact, as they belong to the fibrous structures they will be more properly discussed in the section that treats of these than in this place. Wherever the fibrous cartilage assumes the properties of the cellular cartilage, there the microscopic elements of cell-cartilage are found to increase at the cost, as it appears, of the fibres, which become rarer and rarer. Fibro-cartilage yields no gelatine by boiling.

§ 176. *Ossific Cartilage.*—The transparent element of the bones, hitherto regarded as a hyaline substance in which the bone-corpuscles lie scattered, has been generally designated by this title; but as I shall shew when speaking of the bones that the bone-corpuscles are the nuclei of the bone-cells, and as these have no intercellular matter or hyaline substance between them, it is obvious that the title ossific cartilage, for the transparent element of bone, is improper. Those cartilages, however, that are destined to become bone, and those that can be shewn to exist as the animal element of bone by the agency of acids, might with propriety be spoken of under the name of ossific. The entire skeleton of the bony fishes comes under the same category.*

* In the skate, the secondary cartilage-corpuscles of the skeleton are crowded together in groups precisely as in the cartilages that are destined to undergo ossification. Vide *fig.* 58, A, which is a section from a costal cartilage of the dog. The areas

§ 177. *Normal Ossification of Cartilage.*—The ossification of the costal cartilages which occurs in the domestic mammalia, especially the horse, although incomplete, may still be reckoned as normal, for it takes place invariably. In the full-grown horse the costal cartilages are always found more or less bony; the same thing is observed in the middle-aged dog; and probably it occurs constantly among the carnivora.*

§ 178. The process of ossification that occurs in the cellular cartilages is always essentially of the same kind; in the formation of bone in the embryo, in the renovation and repair of broken bones by exudative inflammation, in the ossification of the cartilaginous epiphyses, as Miescher† has shewn, in the more tardy ossification of the costal cartilages, and finally, in the ossification of the permanent cartilages in advanced age, or under other accidental circumstances—in every case the process is the same.‡ All bony concretions, on the contrary, which

around the groups which indicate the boundaries of the primary or parent cells (B) are still visible in some places. The costal cartilages, therefore, evidently stand on the confines between proper cartilage and true bone.

* See Mr. Gulliver's note, p. 13.

† "De Inflam. Ossium," &c. 4to. Berol. 1836.

‡ In the reparation of fractures some physiologists, as the late Mr. Wilson and Professor Meckel, affirm that the process is just the same as that by which the original growth of the bone took place. There may be certain facts favourable to this doctrine, but there are many at variance with it; for instance, in the course of reparation of fractures of the shafts of the long bones, a cartilaginiform substance is formed quite unlike any structure observable during the original growth of the same part. The cartilaginiform matter is generally abundant when

arise without preceding formation of proper cartilage, such as we constantly find in arteries, in the dura mater upon occasion, in ossified glandular cysts, &c., although the cellular structure cannot be denied to some of them, still they have seldom or never the texture of true bone.

§ 179. *Ossification of the Costal Cartilages.*—If one of the costal cartilages of an aged person, or of a full-grown domestic animal, be cut across slowly with a knife, certain parts or points will be found bony, others in the state of cartilage, and these pass the one into the other. A section of a cartilage beginning to be ossified presents the appearance represented in *fig.* 58. Whilst those parts of the cartilage that are remote from the point or points of ossification are remarkable for a regular dissemination of cartilage cells through their substance, those that are close to it exhibit a clustering or agglomeration of these cells (A) separated by an apparently homogeneous intercellular substance. In these clusters it is not difficult to distinguish cells of older and more recent formation, simple and

there is much displacement of the fragments. Some good examples of it in the lower animals may be seen in the Museum of the Army Medical Department at Chatham,—Division, Experimental Physiology. It may be added, that in fractures of the patella the new bone shoots from the broken extremities into a dense fibrous tissue, quite unlike the cartilage of which the patella is formed at an early period. See my "Experiments and Observations on Fractures of the Patella," *Edin. Med. and Surg. Journal*, No. 130; and "On the Reparation of Fractured Bones," *Ibid.* No. 124. Some illustrative figures are given in the drawings from preparations in the Army Medical Museum at Chatham, fas. 3, plate 9.—*G. G.*

united or blended cells, and smaller and larger isolated nuclei. Where the ossification begins, these clusters are more closely crowded, and are ever more and more distinctly surrounded and enclosed by a delicate line. These lines, speaking of them in the plural, probably indicate primary or parent cells,—those cells which arose in the fœtus on the first formation of the cartilages, and within which the secondary cells (A), the prime means of growth in reference to the cartilages, have arisen. From the part B (*fig.* 58) the primary intercellular substance is opaque, having become so by deposited earthy salts.* Whilst the bone-corpuscles (*fig.* 60, *b*) appear in bone in progress of formation (*a*), the cartilage corpuscles disappear, and bone-cells (*c*) are produced in their stead, and these fill the entire spaces 1. The ossification of the fœtal cartilages proceeds precisely in the same manner.† The cartilage corpuscles, ever more and more crowded together and compressed, cede the space they formerly occupied to the increasing osseous substance; this grows constantly more and more opaque, bone corpuscles make their appearance, then vessels,‡ &c., and the bone is achieved.

* Vide also *fig.* 69, B.

† *Fig.* 69 and reference in Explanation of the Plates.

‡ Every anatomist is acquainted with the vascular beds in which ossification takes place. As soon as an osseous point can be seen, vessels by which the bony matter appears to have been deposited may generally be rendered apparent by the aid of injections. I have not, however, made any particular observations as to whether the bone-corpuscles or the vessels are first produced; but the latter, of course, is the common opinion.—*G. G.*

This process may be explained in the following manner. The secondary hyaline substance, an element included within the primary cells, and in cartilage not to be distinguished from the parietes of the parent cells, is constantly dissolved, and in the fluid state permeates or transudes the walls of the primary cells now become invisible, or it coagulates on the inner aspects of these cells; out of this cytoblastema, cytoblasts (the bone-corpuscles) are formed by coagulation and organization of the new hyaline substance, and from them are produced the bone-cells, which comport themselves in the same manner as the embryonic cartilage-cells; in other words, they form a cellular mass without any interposed matter or intercellular substance. Whilst the recently formed bone-cells are growing, new cytoblasts arise between them and the shrunken parent cells, in the mass of cytoblastema, which is incessantly prepared by the transudation of fluid through the walls of the parent cells, or, it may be, which is laid up by coagulation upon their inner aspects;* the cartilage corpuscles, as said, ever more closely pressed together, disappear; the nuclei of the bone-cells acquire all the while calcareous salts and become opaque; the bone-cells themselves appropriate salts of the same kind, radiated points, nutrient vessels, &c. make their appearance, and the bone is fully formed.

§ 180. The blood-vessels of cartilage which meet the eye, or which are made conspicuous by

* The reverse, consequently, of the mode in which the yolk is formed in the egg, which occurs by a penetration of the cell (the vitellary membrane).

ordinary injections, are so few in number, that it does not seem likely that this substance should derive the juices necessary to its growth and maintenance, by imbibition or endosmose from these alone.* Bone, a less decompoundable tissue, is far more freely supplied with blood-vessels than cartilage; it is, therefore, probable that the vessels of cartilage are more numerous than they are generally supposed to be,† although it must be allowed that cartilage is rarely reproduced, and that wounds of this substance heal slowly, and generally cicatrize at length without any attempt to supply losses.

§ 181. The cartilages, from their various properties—their strength, their elasticity, &c.—are very essential elements in the mechanism of the human and animal body. The ossific cartilages probably lend themselves to the irregular and rapid movements of early life, even better than the harder and less elastic bones would do. The permanent cartilages are employed in the carpentry of parts which, from their function and their posi-

* The late Sir Anthony Carlisle instituted some ingenious inquiries into the mode of growth and reparation of the extra-vascular parts of animals, as the shells of snails, oysters, &c.—*Vide* his paper: "Facts and Observations relative to the connexion between vascular and extra-vascular parts in the structure of living organised bodies," in *Lond. Med. Repository*, vol. iv. p. 89 (1815); and in Thomson's *Annals*, vol. vi. p. 174. Some interesting observations on the same subject were recently communicated by Mr. Toynbee in a paper read at the Royal Society.

† We are indebted to Mr. Liston for an admirable demonstration of the existence and arrangement of the blood-vessels of diseased articular cartilage.—Vide *Trans. Med.-Chir. Soc.* vol. xxiii.—*G. G.*

tion, evidently require elasticity and yet firmness in their construction: in such parts, for instance, as the external ear, the larynx and trachea, the extremities of the bones where they form articulations, &c.

BONE.

§ 182. The bones may be said to be produced immediately from the mutable cartilages, and they are well known to be readily reduceable to the state of cartilages again, which retain the precise structure of the bones from which they were obtained. Bones are hard in the ratio of their density, and of the quantity of calcareous salts they contain.* They

* It has been commonly supposed that the difference in the physical properties of the bones of the blood and cart-horse are connected with a marked difference in the proportions of the earthy and animal matter; but Dr. Davy's observations are opposed to this opinion, as will appear from the following extract from his "Researches," vol. i. p. 394:—

	Calcareous Matter.	Animal Matter.
Pure-bred horse,— metatarsal bone, specific gravity 1854, and after having been subjected to air-pump, 2033	65·77	34·23
Low-bred troop-horse,—metacarpal bone, specific gravity before action of air-pump 2010, and 2077 after	65·78	34·22
Blood-horse,—compact part of shaft of humerus, before being subjected to air-pump, specific gravity 2045, and 2092 after	69·44	30·56
Dray-horse,—similar part of humerus, before action of air-pump, specific gravity 2000, and 2126 after	70·8	29·2

Dr. Davy further remarks, after a table of the proportion of animal and calcareous matter in diseased bones, what very slight agreement there is between the quality of hardness and of softness of bone, and the proportions of calcareous and animal are of a yellowish, a bluish, or reddish white in different instances, and they possess a very considerable degree of elasticity. The specific gravity of bone varies considerably, being in relation to the density and amount of saline impregnation of the specimen examined; it generally lies between 1·80 and 2·03.* The animal matter of bone is easily removed by the action of caustic alkali and of a high temperature If the bone be exposed to heat in contact with air, the remaining earthy matter coheres much less firmly than it does when the exposure is in a close vessel or without the access of air; the animal matter, in the latter case, is only charred, and the bone retains its shape in great part, and, in some measure, its consistency. Dilute acids remove the earth, and the cartilage remains behind. The cartilage of the fœtal bones is but very sparingly soluble in water, and does not yield proper gelatine by long boiling; the cartilage of the bones of adult animals, on the contrary, is in a great measure and readily soluble in boiling water, and yields an abundance of jelly.† The calcareous salts of the bones lessen the liability of the component cartilage to undergo decomposition in so notable a manner, that they decay with extreme slowness; hidden in the earth, or sunk in water, they proclaim

matter, confirming the conjecture that more seems to depend, in relation to these qualities, on the arrangement of the ingredients than on their respective proportions.—*Researches, Phys. and Anat.* vol. i. p. 403.—*G. G.*

* See Dr. Davy's "Observations on the Specific Gravity of different parts of the Human Body."—*Researches*, vol. ii. p. 253.

† *Vide* note to § 172.

the existence, at periods variously remote from that in which we live, not only of numerous species, but of entire genera of animals that are now extinct. These fossil organic remains, as they are called, sometimes differ, as regards their state, in nothing from bones of existing animals that have lain long in the ground, or been long exposed to the action of water. At other times, however, they are truly *mineralised*, having become penetrated with calcareous or siliceous matter, when they are as hard and unchanging as jasper or marble.* Even when thus penetrated, bones retain their structure, a circumstance which is at once apparent when a thin slice is placed under the microscope.†

* In the parietal bone of a skull probably 3000 years old, from an ancient tomb at Cerigo, Dr. Davy found 26·2 per cent. of animal matter; and in a bit of the zygomatic process of an ancient Egyptian cranium from a tomb at Thebes, there was 23·9 per cent. of animal matter. "In the bone-breccia of the Mediterranean, so widely scattered, I have been able to detect a just perceptible trace only of animal matter; and in the teeth of the squali, which occur in the tertiary formations of Malta and Gozo, I have not been able to detect even a trace of it. In an enormous tooth of one of these fishes now in my possession, I carefully sought for animal matter, but in vain. They and the fossil bones generally which have not been exposed to the air, owe their strength and hardness to a kind of cement of carbonate of lime, which they all acquire. Judging analogically from the partial effect of a known period of time, what an idea of vast antiquity is conveyed by the circumstance of the total destruction of the animal matter of bones!"—*Researches, Phys. and Anat.* vol. i. p. 399.—*G. G.*

† This circumstance has recently been taken advantage of, more especially with reference to the teeth, in determining the species or family to which the animal belonged, of whose skeleton some small fragment only is discovered. With a piece of a

The bones, with the exception of the crowns of the teeth, are inclosed by the fibrous periosteum. The *long bones* of mammals contain the marrow, which is merely a finely cellular fat, inclosed within the lining membrane of their internal cavities. The *flat bones* consist of two tables, separated by a cancellar, or spongy substance, called *diploe*, which is either occupied with marrow, or is hollow, in which case it is lined with a delicate mucous membrane. The cubical, or rounded bones, such as those of the carpus and tarsus, and those of a mixed character, consist of a spongy tissue with included medullary cells or cavities, and are commonly bounded by a very delicate layer of dense or vitreous bony substance.

§ 183. The developement of the bones in the fœtus takes place sooner or later in different species of animals, according to the time which the embryo itself requires for attaining the maturity that will fit it to begin an independent existence. The bone-cells begin to be formed in certain points —centres of ossification: these are aggregations of oval bone-cells, from which the ossification spreads over the rest of the cartilage. Small rounded bones have usually but a single centre of ossification; irregular bones again have several centres; cylindrical bones have at least three, one in the middle, and two others for the epiphyses or end portions.

tooth we can generally say that the skeleton of which it formed a part was that of a mammal, a reptile, or a fish, and often even make more particular deductions.—*G. G.*

Microscopic Analysis of Bone.

§ 184. A delicate slice of a cylindrical bone under a low power exhibits (vide *fig.* 61) canals (*b*, *c*), which for the most part run parallel with one another (*b*), and are connected by cross or anastomosing branches (*c*). In the recent bone these channels contain blood, which during life is conveyed by the nutrient vessels that enter and quit the bone in different places. The spaces between the vessels (*a*) constitute the proper substance of the bone; this consists of bone-cells, the nuclei of which are called bone-corpuscles. These in *fig.* 61 appear as simple points; under a higher power, as in *fig.* 70, they have distinct and definite forms.

From the elongated bone-corpuscles (*a*), which are without obvious nucleoli, extend fine radiations, the canaliculi chalicophori of Müller, on every side to the confines of the cell (*b*). A good view of the cells of bone is obtained by inspecting a delicate transverse section of one of the grinding teeth of the horse (the appearances are represented in *fig.* 68); the cells are seen extending from the bony substance *a*, *b*; *a′*, *b′*, half way into the enamel *b*, *b′*. These cells all contain a nucleus, some of them contain two. The same structure may, however, be demonstrated here and there in a fine section of any bone, by soaking it first in a solution of nitrate of silver, drying it, and then dipping it in a solution of common salt, after which it must be polished. These cells of bone do not appear to have any vitreous substance interposed between them. They surround the vessels (*fig.* 65, *c*), in the form of concentric laminæ (*b*), and lie betwixt them with more or less of an obvious parallel arrangement (*a*.)*

In the flat bones the vessels form a common network (*fig.* 66). The spongy bones in general consist of a reticulation of compact bony substance, which encloses cavities full of fat cells.

§ 185. In the embryos of our larger domestic animals we discover the incipient ossific points about the sixth week from conception; in the common fowl they are visible as early as the ninth day, and in some of the bones bone-corpuscles are even then already obvious. The ossification extends from these points, in rays in flat bones, in long bones in the direction of their length.

Some bones are earlier formed than others: the lateral portions of the bodies of the vertebræ appear at a very early period, and between the two rows which they form lies the chorda dorsalis. The separation exists in the calf in the eighth week; the lateral parts of the vertebral arches are only united towards the tenth week. Ossification in the bones of the head begins in the lower jaw, then in the os frontis, and next in the circumjacent bones of the face. The middle portions of the ribs are ossified at an early date; and nearly simultaneously, the middle portions of the great bones of the extremities shew points of ossification, the thoracic extremities being always somewhat in advance of the abdominal limbs. The smaller bones of the extremities follow, and finally the square or rounded

* Consult the figures from 61 to 66 and the appertaining explanations of the plates.

bones of the carpus and tarsus. The blood-vessels are relatively larger and more numerous the younger the bone is. No nerves other than those that penetrate along with, and apparently belong to, the blood-vessels, seem to exist in bone.

Chemical Constituents of Bone.

§ 186. Bones subjected to dry distillation in closed vessels yield an empyreumatic oil, an empyreumatic acid, carbonate of ammonia, and a variety of gases; and there remain behind carbon, phosphate of lime, and a little phosphate of magnesia. In Papin's digester the cartilage of bone is dissolved out, and appears in the shape of gelatine.

In the adult the cartilage forms about one-third part of the whole mass of a bone. One hundred parts of the dry bone [of the horse?] were found to consist of

Cartilage	32·17
Vessels	1·13
Basic phosphate of lime with a trace of fluate of lime	53·04
Carbonate of lime	11·30
Phosphate or carbonate of magnesia	1·16
Carbonate of soda with a little chloride of sodium	1·50
	100·30

§ 187. In the fœtus and young creature the animal matters predominate; the earthy increase with age; so that the older the individual, the harder and more brittle are the bones.* The carbonate of

* The proportion of calcareous and animal matter varies under circumstances which do not yet appear to have been pre-

lime which is found in the skeleton of the mammal is typical of a lower grade of organization than the phosphate of lime; the former predominates at the bottom, the latter at the top of the scale of animate

cisely explained. Thus in recent bones, from a young person aged about 15, Dr. Davy obtained the following results, viz.—

	Calcareous Matter.	Animal Matter.
Parietal bone	58·8	41·2
Tibia	53·6	46·4
Fibula	44·0	56·0
Ilium	45·0	55·0
Femur	47·0	53·0

Dr. Davy's analyses shew that the proportion of earthy matter does not always increase with age, as in the following examples, in all of which the parietal bone was the subject of experiment; and the specimens were previously thoroughly dried, by exposure to a temperature of 212°, till they ceased to lose weight,—a circumstance, as he justly remarks, of some importance in comparative experiments:—

	Calcareous Matter.	Animal Matter.
From a man æt. 20	66·9	33·1
Ditto æt. 31	70·2	29·8
Ditto æt. 52	68·5	31·5
Ditto æt. 45	66·6	33·4

The bones of young children are known generally to possess a smaller proportion of earthy matter than those of adults; yet to shew how perplexing, in the present state of our knowledge, the subject is, the subjoined analyses are selected:—

	Calcareous Matter.	Animal Matter.
Lower jaw of an old person (No. 10, p. 385)	56·6	43·4
Ditto of a child (No. 6, p. 392)	57·2	42·8
Ditto of a fœtus, between five and six months (No. 9, p. 393)	56·0	44·4

These results, of course, are at variance with the majority, but they are well calculated to excite further inquiry.—Vide *Researches, Phys. and Anat.* vol. i. p. 384, *et seq.*—*G. G.*

creation; and in morbid discrasiæ the carbonate sometimes appears at the cost as it were of the phosphate, and this, too, by so much the more as there is a greater amount of alteration of structure. In this state of things it is very common to find associated a partial metamorphosis of the fibrinous tissues (vide § 96),—a conversion of cartilage into fat, for instance.*

§ 188. In the OSTEOLOGY the bones are particularly considered in all that regards their forms, processes and elevations, their pits and depressions, their connexions, &c. &c.

§ 189. *Projections.*—When elevations form immediate continuations of bones they are called *apophyses;* when they are separated from the bones by a layer of cartilage, they are denominated *epiphyses.* These last are ossified from a distinct point, and only become united to the bones upon which they are placed by the gradual ossification of the connecting cartilage, when they are changed into apophyses or processes. The consideration of the various forms of bony process belongs to the

* In Dr. Davy's work on the Interior of Ceylon is an account of the dissection of a leg in which a large quantity of oil was found in the capsule of the knee joint in the place of synovia: the case was one of elephas. The substance of some of the viscera of carnivorous animals which have died in confinement is often gorged with oily matter. In the parenchyme of the kidneys of the leopard, for example, though these organs appeared otherwise healthy, and the animal was generally not fat, I have seen so much oil that it might be pressed out in considerable quantity. Some preparations shewing the fact were sent to the Museum of the Army Medical Department at Chatham.—*G. G.*

descriptive anatomy, so that it will be enough in this place to enumerate the different kinds that have been specified; these are:—

1st. *Capitular processes:* articular terminal surfaces of a more or less rounded form covered with cartilage. 2d. *Button-like processes,* connected with the bones by a broad base, covered with cartilage, smooth, round, and serving as means of articulation. 3d. *Eminences of impression and of reflection, and odontoid processes.* 4th. *Trochanters, tubers, tuberosities,* strong, rough processes for the attachment of muscles, ligaments, &c., and serving as levers. 5th. *Ridges,* long, linear, sharp, and rough margins upon flat bones. 6th. *Lines,* long, little-raised ridges. 7th. *Spines,* long pointed processes.

§ 190. *Depressions.*—These either include articular processes, and are therefore covered with cartilage and smooth; or they lodge or enclose certain organic parts; or they constitute cavities or sinuses of different capacities, which are covered with mucous membranes. The following kinds of depression have been enumerated:—

1st. The *deep* and *shallow articular depressions*—the *cotyloid* and *glenoid cavities.*—These receive the more or less perfectly globular heads of bones for the constitution of joints having the freest motions. 2d. The *trochlea, groove,* or *channel,* an elongated shallow depression. 3d. The *canal,* a complete or close channel. 4th. The *foramen* or *hole,* a depression that passes through a bone. 5th. The *cleft,* a fine slit passing across some portion of a bone. 6th. The *notch* or cleft that does not go completely through the bone, and gets narrower as it goes deeper. 7th. *Sinuses* or *antra;* these are hollow spaces lined with mucous membranes between the tables of flat bones.

§ 191. *Connexions.*—Bones are connected in different ways with one another according to the properties and uses required in the articulation. Sometimes they are freely movable one on another—*diarthrosis;* sometimes the motion is very limited—*amphiarthrosis;* and sometimes it is nil—*synarthrosis.* 1st. In the *movable articulation,* the opposed ends of the bones are covered with articular cartilage, and fashioned severally for the encounter that takes place, enclosed within a common synovial capsule, and kept together without any implication of the required movement by means of ligaments. The movable articulation is divided into different kinds: (*a*), the *enarthrosis* or *ball and socket joint,* such as those of the hip and shoulder; (*b*), the *hinge* or *ginglymus joint,* like those of the knee, ankle, &c.; (*c*), the *pivot joint,* of which a perfect example is furnished in the articulation between the atlas and vertebra dentata; (*d*), the *arthrodial* or *limited joint,* of which we have examples in the articulations of the carpus and tarsus, where the bones merely glide backwards and forwards for a little way upon one another.

2d. In the mixed or *amphiarthrose* articulation, the bones are connected by some interposed substance,—cellular or fibrous cartilage. The motion here is entirely referable to the elasticity of this interarticular substance: we have examples of it in the intervertebral and pelvic articulations.

3d. In the *synarthrosæ* or *immovable articulations* the bones abut immediately upon one another, and their union is accomplished variously: (*a*), by *suture*, when the edges of the bones penetrate each other mutually by jagged offsets; (*b*), by *scyndelesis*, when a ridge in one bone is received into a furrow of another; (*c*), by *harmony*, or false suture, when the edges of the bones merely meet without penetrating each other by large and obvious offsets; (*d*), by *gomphosis*, when a part is implanted in the manner of a wedge or nail, as are the teeth in the alveoli of the jaws.

§ 192. The skeleton is the foundation and frame-work of the animal body, a system of props and levers for the muscles of voluntary motion to accomplish the behests of the mind withal; a means of forming various cavities in which the viscera are contained. Its parts, like all the rest that belong to voluntary motion and sensation, are symmetrical and in segments; in other words, an antero-posterior plane divides it into two equal halves, so that on the right and on the left side similar bones in like number are encountered, and in the middle line or plane of section single bones, but divided into two similar halves.

The skeleton is divided into head, trunk, and extremities. In the head we distinguish the bones of the cranium and those of the face. In the trunk we have the vertebral column, the ribs, the sternum, and the pelvis. The anterior, atlantal, or thoracic extremity consists of the scapula, clavicle (where present), humerus, radius and ulna, carpus or wrist, metacarpus, and digital phalanges. The posterior, sacral, or abdominal extremity comprises the femur, tibia and fibula, tarsus, metatarsus, and digital phalanges. The accessory bones—the os hyoides, sesamoid bones, marsupial bones, os penis, &c., are connected variously with the proper skeleton by means of cartilage or ligament; but the cardiac bone of the ruminants has no connexion with the skeleton at large, and belongs to another organic system.

TEETH.

§ 193. The teeth were long and uniformly, by all the early writers on anatomy, classed among the bones; but by and by, and under the influence of new views, they came to be reckoned among the horny tissues, and this not without apparent reason; for, though the teeth in point of chemical composition and texture belong obviously to the bones, still in their extrinsic situation, their mechanical relations to external things, and their connexions with the processes of the corium which engender and continue to maintain them, they as evidently appertain to the cuticular formations, and bear a close affinity to the nails and hair. The most recent inquiries of all, however, those of Miescher, J. Müller, Retzius, [Nasmyth, Owen], &c. have clearly shewn the teeth to be modified or epithelial bones, so that they cannot now be detached from the osseous system.

In the teeth of the lower animals, as many as three different substances are readily distinguished: 1st. the *enamel* or vitreous substance; 2d. the *proper substance* or ivory; 3d. the *bone* or cement.

§ 194. *Enamel, Vitreous Substance.*—This is the hardest part of the teeth, and indeed of the animal body; it is, however, brittle, of a bluish white colour, and semi-transparent; it generally forms the outermost layer of the teeth; although any interchange of substance is hardly conceivable in the enamel, it nevertheless maintains its appearance and properties unchanged through the whole period of life; it is, in fact, only affected by drying, an elevated temperature, and acids. In man, and the quadrumana and the carnivora, it forms the outer layer of the crown;* but in the horse and the ruminants it is covered by a crust of bony substance (*fig.* 67, *a*, bony substance, *b*, enamel). On the rubbing or grinding surface of the teeth of these animals, however, it always projects more than the other parts, its greater hardness preserving it from wearing down by attrition in the same degree as these. In man and the carnivora, and in the incisors of ruminating animals and the hog, the enamel forms a simple external layer, and so surrounds the other substances on the crown; in the grinding teeth of the horse and ruminantia, again, it is inverted upon the rubbing surface into the bony substance of the tooth, so that when the edges of the inverted portion are worn off, it forms two layers, between which the proper substance of the tooth is conspicuous, one layer being external (*fig.* 67, *b*), another internal (*e*), including, as just said, the ivory or proper substance of the tooth (*c*) between them. The hollow of the involuted layer of enamel in the grinding teeth of the horse, is filled up by the external bony substance (*f*).

* *Vide* note, p. 200.

Microscopic Examination of the Enamel.

§ 195. The enamel (*fig.* 68, *b*, *m*, and *g*, *h*), consists, according to Purkinje, of closely compressed four cornered (Retzius* says six cornered) slightly bent prisms, which stand in the direction of the lamellation or axis of the tooth nearly perpendicularly, so that the one end is either external and free, or external and in contact with the outer layer of bony matter, as in the horse (*fig.* 68, *b*), the other end being internal and directed to the proper substance of the tooth (*fig.* 68, *f*);† in the involuted portions, of course, the reverse of this arrangement obtains (*fig.* 68, *b*, *m*). The prisms are indicated in *fig.* 68 by the fine lines *h*, and as they present themselves under such a power as the one employed; inspected from the base and highly magnified, they appear as in *fig.* 72, *b*, or in *fig.* 186. The enamel of a delicate section of a tooth, when magnified, has a yellow colour, and is separated by an intermediate brown streak from the greyish-blue coloured substance of the tooth. The prisms of the enamel unite with the bone cells which half penetrate the enamel (*fig.* 68, *b*, *b*) in the same way as the fibres of the tendons unite with the conical ends of the primitive muscular bundles (*fig.* 51, *a* at 1).

§ 196. In the fœtus the enamel is enclosed by a

* Müller's "Archiv." 1837, S. 486. Taf. xxi.

† A transparent layer of basalt would convey, on the great scale, a good idea of the arrangement of the enamel prisms. The enamel also resembles, to a certain extent, a compressed cylinder-epithelium (*fig.* 46, *b*, *c*).

membrane which, according to Schwann, is beset internally with cells, which are prolonged from the surface of the membrane inwards, and form the enamel-needles or prisms, which, as they grow, are ever more and more compressed, so that they become six sided by their mutual contact, whilst they are becoming ossified and their nuclei are disappearing. These cells can be shewn still to exist in the enamel by the agency of dilute hydrochloric acid.

Chemical Composition of Enamel.

§ 197. Pure enamel contains very little animal matter; it consists almost entirely of inorganic substances, viz.:

Phosphate of lime and fluate of lime	88·5
Carbonate of lime....................	8·0
Phosphate of magnesia................	1·5
Animal matter, alkali, and water........	2·0
	100·0

Proper substance; Tubular substance; Ivory.

§ 198. The *Proper Substance* forms the largest portion of the tooth, and, at the same time, constitutes the kernel of the structure. It extends from the apex of the fang to the rubbing surface of the crown, which, in worn teeth of the human subject, together with the investing crust of enamel, it composes entirely. On the grinding surface of the teeth of the horse, where there is an involution of the enamel, it is contained betwixt the outer and inner layer of this substance (*fig.* 67, *c.*; *fig.* 68, *k*, *l*, *k*). To the naked eye the proper substance appears slightly semi-transparent, yellowish in colour, and finely streaked, or fibrous; polished, it becomes nacreous and opalescent. It is harder than other bone, but not so hard as enamel. In the long axis of a tooth we observe an elongated canal, the *canal of the tooth* (*fig*. 68, *l*.), which opens at the root, or fang, and extends towards the grinding surface, increasing in width as it advances. In this canal are contained the vessels and nerves of the tooth, and the younger the tooth the more ample is the canal, or cavity. In the fœtus, and in early life, it in fact contains the *pulp* of the tooth, the part which, according to the views of physiologists of the last age, *secreted* the tooth, [which, according to present opinions, is *converted* into the tooth, having calcareous salts deposited in it, in the same manner as ossific cartilage in other situations].

§ 199. *Microscopic Analysis of the Proper Substance.*—In fine slices of teeth, the proper substance appears of a bluish-grey tint, it is an otherwise homogeneous hyaline substance, penetrated by delicate, slightly sinuous, cylindrical tubuli, lying close and parallel to one another (*fig*. 68, *k*, *l*, *k*,), beginning with fine openings in the central canal (*l*), and running obliquely outwards and towards the crown. When they reach the enamel, or, as happens in the roots of the human teeth, the bone, they ramify very minutely, and seem to penetrate the enamel, or the bone itself; with these fine ramifications, true bone-corpuscles are connected, a fact which, after Retzius, I have ascertained distinctly in examining the teeth of the horse. The tubuli in the fresh and living tooth, contain a reddish fluid; they are too minute to admit the blood corpuscles.

The proper substance is developed in the fœtus from cells which, undergoing elongation, their extended and hollowed nuclei at length form the tubuli. The ramifications of the tubuli, especially towards the extremities at and in the enamel, present precisely the same appearance as the radiations of the bone-corpuscules. The cells are produced by the pulp, from which fine fibres pass into the tubuli.

§ 200. *Chemical Composition of the Proper Substance.* — The substantia propria appears to possess different degrees of hardness in the teeth of different families of animals, and to contain its constituent elements in different proportions. In the mammalia it has been found to consist of —

Animal matter	28·0
Phosphate of lime and fluate of lime	64·3
Carbonate of lime	5·3
Phosphate of magnesia	1·0
Carbonate of soda and a trace of common salt	1·4
	100·0

Bone of Teeth; Cement; Crusta Petrosa.

§ 201. In the simple teeth of man and the carnivora, the bone is met with as a simple layer covering the fangs; in the teeth of the ruminantia and other animals, however, the horse, for example, where there is involution of the enamel, the bone is met with as a double layer, first surrounding the teeth entirely (*fig*. 67, *a*, *a*, *a*), and then inverted into their substance (*f*), from the grinding aspect through the middle of the crown, to the place of its transition into the root.* Here the bone presents itself in the guise of a piece let into the enamel (*e*). In the young tooth there exists a brown coloured depression in the middle (*g*), which, in the incisors, has the shape of a compressed cone ; this constitutes what is called the *mark* of the horse's tooth.

The bone is the softest part of the tooth ; it is less transparent than the other elements. It is of a milk-white colour within, externally it is often yellowish. It is only produced after the enamel and ivory have been formed, and is rather to be viewed as a crust superadded to the tooth, than as an essential portion of its structure.

§ 202. *Microscopic Analysis of the Bone of Teeth.*—The internal and external bony substance present the same appearances under the microscope : they look like ordinary dense bone. Their bone-corpuscles (*fig.* 68, *d*) are of large size, and lie in layers concentrically disposed, and that increase in thickness externally (*c*, *c*) ; the radiations proceeding from these corpuscles, however, are never so distinct as they are from those of ordinary bone ; occasionally the limits of single bone-cells may be detected towards the line of contact between the

* The recent observations of Mr. Nasmyth would lead us to believe that the simple teeth of man and the carnivora were invested precisely like those of the ruminants, &c., by a continuous but very delicate film of cement. In the human subject, Mr. Nasmyth succeeded in tracing this film on the whole surface of the enamel and fang of the tooth in one continuous envelope, and he even removed it from the crown in the form of a distinct capsule. He proposes to term it "the persistent dental capsule."—Vide *Med.-Chir. Trans.* vol. xxii. p. 312. London, 1839.—*G. G.*

crust and the enamel, where the cells are seen actually to penetrate the enamel (*b*, *b′*). The crusta petrosa has its blood-vessels like bone, running in canals, but they are few in number; they are of considerable size, however, and generally course from within and from the root outwards and towards the crown.

§ 203. In a chemical point of view, the bone or cement appears to be of the same essential nature as the compact or vitreous portion of common bone, with this difference, that the quantity of its earthy salts is relatively greater. In adult and old ruminants the crowns of the teeth may often be observed shining with a metallic lustre as if they were bronzed; this is owing to the deposition of many fine strata of concrescible matter from the saliva.

External Form of the Teeth, and their Relations to the Jaws.

§ 204. The teeth vary in number, form, position, relations to the jaws, &c. in different animals. They are essential parts in the economy of the mouth and serve in man and the mammalia for the prehension and division or trituration of the food, sometimes as weapons of offence, and sometimes as means of separating the newly-born offspring from the after-birth.

According to their form and destination teeth are divided into incisors, laniarii or canines, and grinders. The crown projects beyond the gum; the root is concealed by the gum and alveolus, and in the incisors and canines is simple, in the grinders compound. Between the root and the crown a constricted portion is apparent in some teeth, and this is the *neck* of the tooth, the part which is embraced by the edge of the gum.

In the intermaxillary bones of the solidungula, of the hog and of the carnivora we find six incisors, opposed by the same number in the under jaw,—twelve therefore in all; the number of incisors in man is eight in all. The intermaxillary bones of the ruminantia are toothless; the lower jaw, however, is furnished with eight shovel-shaped incisors. The incisors, whether opposed or not, serve for the prehension of the food in the lower animals. The canines in our domestic mammalia are somewhat curved in their form, and stand isolated or apart, midway between the incisors and grinders. The stallion has four of these teeth, which are called tushes; in the mare they present themselves as mere rudiments. The canine teeth serve as formidable means of offence in some cases, as in the boar; and in the carnivora as powerful instruments for securing and tearing a prey.

The molar teeth are generally present in equal number in the upper and lower jaw. In man and the hog the crowns of these are divided into from two to four points; in the carnivora they are narrow and sharp, and act like the blades of scissors; in the frugivora again they are broad and rough, the inequalities on the grinding surface being maintained by the different degrees of hardness possessed by each of the three substances entering into the constitution of the teeth (*fig.* 67). The grinders have from two to four roots. In man they are twenty, and in the horse, ox, and sheep, twenty-four in number; the hog has as many as twenty-eight of these teeth; the dog has twelve in the upper jaw and fourteen in the lower jaw.

§ 205. The replacement of the deciduous or milk set of teeth by the permanent set, which occurs in youth, extends to all the incisors; to the cuspidati in man, the dog, and the hog; to the eight most anterior molars in man, and to the twelve corresponding teeth in the horse, ox, and sheep; in the dog, to the second, third, and fourth molars; in the cat, to the second and third in the upper jaw, and to the first and second in the lower jaw.

Formation of the Teeth in the Fœtus.

§ 206. This begins at an early period. Within the alveoli *sacs* filled with a liquid cytoblastema are first produced, within and from which, but connected with the sacs, arise, perhaps from the nuclei of the parent cells, simple or internally wrinkled vesicles, —the germs or *pulps*, which prefigure the crowns of the future teeth. Each molar tooth is evolved from several such vesicles. The three substances of the future teeth are produced by a like number of distinct layers of cells, comparable to the three layers of the germinal membrane, which soon ossify and exhibit the hollow shell of the crown, in which the cytoblastema gradually fashions itself into the pulp, whilst externally it is used in forming the tooth; the crown of the tooth is strengthened by constant additions from the pulp within, and augmented in size by additions from the enamel-membrane without;

(the internal cavity of the tooth is consequently continually lessening). Meantime the root is growing, and with its progress the tooth is rising from the socket, until it finally bursts through the outer layer of the gum, and comes into contact with the corresponding tooth of the opposed jaw which has been developed in the same manner.

OF THE TISSUES.

§ 207. The organic structures, composed for the most part of similar elements, are commonly spoken of under the title of *tissues.* I mean to restrict this appellation to those that are made up of fibres and filaments, as the name seems to me well applied here, but to be used amiss with reference to the structures designated hyaline, and to those that consist essentially of cells; for example, the adipose, pigmentary, horny, cartilaginous and osseous. The proper tissues comprehend elastic tissue, fibrous tissue, and filamentous tissue; the last being subdivided into cellular, tendinous, ligamentous, fibro-cartilaginous, contractile, and muscular.

ELASTIC TISSUE—INTERCELLULAR RETE.

§ 208. To the naked eye the elastic tissue appears as a fibrous, pale chrome or ochre yellow coloured, dull texture: it is generally seen in the shape of soft membranes either alone or connected with cellular tissue, tendons, cartilages, &c.; it forms an integral part of all the elastic membranes; it possesses such elasticity that it can be drawn out very nearly to twice its original length, and yet contract again to its old dimensions. It is divisible into flat strings, and is much more easily torn than any of the structures composed of round filaments; the torn ends and edges are regular and smooth. The component fibres and fasciculi of elastic tissue interlace freely in different directions, and form smaller meshes and larger interspaces. This arrangement is very conspicuous in the ligamentum nuchæ of the solidungula and ruminantia. Elastic tissue appears to be scarcely more sensitive than bone. It is very sparingly supplied with vessels; and of special nerves it seems to have few or none.

§ 209. *Chemical Analysis of Elastic Tissue.*—The chemical constitution of elastic tissue appears to be peculiar; but the point has as yet been little investigated. It yields no gelatine by long boiling, and is, indeed, so little affected by boiling water in its texture, colour, and general physical properties, that this agent, so powerful in its effects upon the animal textures at large, may be said to be impotent as regards the elastic tissue.* It may be kept in alcohol for years without undergoing any change. Left to itself, it putrifies with difficulty; macerated in water its superficies becomes changed into a

* After ten hours' boiling in water, Dr. Davy found that the middle coat of the aorta and pulmonary artery was rendered more friable, but not more transparent, and not in the least gelatinous: it was less weakened and altered by the operation than muscle. The effect of long continued boiling on the ligamentum nuchæ of the ox was similar. "On the Effects of Boiling Water, and of Boiling, on the Textures of the Human Body after Death."—*Researches,* vol. ii. p. 322.—*G. G.*

slimy-looking matter; internally the structure remains for a very long time unchanged. It is also found powerfully to resist the process of digestion. Dried it becomes brown, transparent, but not brittle as do the cellular cartilages; bent backwards and forwards repeatedly or beaten, it separates into white fibres like whalebone.

§ 210. *Microscopic Analysis, Origin and Developement of Elastic Tissue.*—In the mode of its developement, and the nature of its elements elastic tissue differs essentially from the other fibrous and filamentous formations, bearing great affinity to the ossific cartilages. In the embryonic mass of cells destined to the formation of elastic tissue, stratifications are observed like those of the multilamellar cuticles. The cells suffer elongation in the direction of the future fibrillation, and become flatly fusiform, as in the fibrils of cellular tissue, but they do not cohere in this instance; they remain isolated with sharp pointed extremities amidst the consolidating intercellular substance. In the parent cells of elastic tissue, as in those of cellular cartilage, new secondary cells are abundantly produced. Whilst the intercellular rete of the stratified cellular membranes becomes independently organised, the cells themselves are either dissolved and disappear, or they remain for long periods, or, finally, they endure for the whole term of life. In this way, in all likelihood, is the pure elastic tissue every where produced,—a tissue which, in the mode of connexion of its fibres, bears the strongest resemblance to the capillary vascular rete, as may be seen by comparing the highly magnified teased-out piece of elastic tissue from the middle coat of the aorta represented in *fig.* 55, with the less strongly magnified capillary vascular rete of the bones of the skull depicted in *fig.* 66, and with other representations of capillary reticulations, those, for instance, of *figs.* 140, 144, and 145; the continuous elastic tissue of the ligamentum nuchæ (*fig.* 54) may also be contrasted with the capillary vessels of a muscle (*fig.* 142). The transition of the intercellular rete with polygonal meshes into a continuous elastic tissue, I have endeavoured to represent in *fig.* 225.

§ 211. The fully formed elastic tissue consists of prismatic, frequently four-sided, rigid fibres, from the $\frac{1}{350}$th to the $\frac{1}{400}$th of a Paris line in diameter. These fibres are even in their course, and sharply defined; they divide furciform fashion, and inosculate at all angles from the most acute to the most obtuse. The intervening meshes which result from these interlacings and anastomoses are here of like form and magnitude: they are of the most dissimilar shapes and sizes. The fibres individually as well as collectively are highly elastic.

The elastic tissue of the ligamentum nuchæ belongs to the regular and continuous class of such structures. Its fibres are straight, from four to six-sided; its meshes are so long relatively to their breadth, that they seem often scarcely to form a slit (*fig.* 54, *b*). The structure is only rendered conspicuous when the band is stretched laterally (*a*).

The elastic tissue of the fibrous or middle coat of the arteries is much more irregular and intricate (*fig.* 55). The fibres here are of different thicknesses; they are frequently flat, and the meshes of different sizes, and mostly polygonal or rounded in figure.

The elastic tissue is also commonly enough met with very free from admixture, in the *yellow* ligaments and membranes: such, for example, as the anterior and posterior bands that pass between the first vertebra of the neck and the os occipitis, the bands that connect the arches of the other vertebræ, all the yellow bands or ligaments of the os hyoides and larynx: for example, the hyo-epiglottidean band, the hyo-thyroid bands, the thyro-epiglottidean band, the thyro-arytenoidei bands, &c. Farther, the yellow membrane, which in the horse especially, covers the pectoral portion of the serratus magnus and the fleshy origins of the external oblique of the abdomen, and then expands and is lost in fine tendinous-looking fasciæ. The elastic tissue also occurs mingled with the proper element of other aponeuroses; and it even constitutes an integral part of the skin and mucous membranes. In the cartilages of the external ear and of the epiglottis, and indeed of reticular cartilage generally, it forms a constant element. In some places its meshes are seen filled with single or with several cartilage-cells, or with cells and nuclei together (*fig.* 59).

Even in fibrous cartilage elastic tissue appears very constantly to exist mingled with the proper cartilage-fibres.

A delicate elastic tissue enters into the structure of various parts of the eye-ball; of the ciliary ligament, for example (*fig.* 56, 1), and of the iris (2), where its meshes are relatively large. The elastic fibres that are readily demonstrated in the finer ramifications of the bronchi (*fig.* 49, C), and in the coats of the larger veins, are of the same undulating and delicate character as in the eye.

The blood-vessels of elastic tissue form a scanty and wide-meshed reticulation. I have never been quite certain of having seen its proper nerves.

Elastic tissue is found in every situation where a high degree of elasticity and mobility is required. The middle coat of the arteries reacts powerfully, by its elasticity or elastic contractility, upon the blood thrown into them at each stroke of the heart: the vessels then yield, and the pulse is felt; but the vessels by their resilience immediately shrink again, and press on the column of blood in one continuous stream, acting in the same manner precisely as the air-vessel in an hydraulic machine.

Elastic tissue, if injured, is very imperfectly reproduced; it is, in fact, replaced by a dense fibrous cicatricular substance.

§ 212. For the sake of natural connexion, it becomes necessary to remark here, that the rudimentary matter out of which the capillary rete of the blood-vessels is formed, as well as that from which elastic tissue and bone are produced, is, in all probability, to be sought for in the primary intercellular substance. Not only do the forms of the hollow fibrous reticulation, in other words, the capillary vascular rete (*fig.* 213), accord with those of the loose elastic tissue, and the primary intercellular net of the cartilages which is afterwards changed into spongy bone (*fig.* 60); but in number and dimensions the vascular meshes seem also to agree with those of the cells secondarily evolved from parent cells, as we see them in the ossific cartilages.* That the vascular capillary rete, and likewise the elastic tissue, arise from hollow cells connected in the manner of a net (*vide* § 132), and originally produced in the intercellular substance, is more probable on analogical grounds, than that the intercellular substance should, without further secondary cellular formation, become hollow. It must be allowed, however, that varicose enlargements or spindle-shaped cells are very rarely seen in the course of the elastic fibres, or at the points of their inosculations, during the period of their developement. An abundance of such enlargements and cells, nevertheless, is constantly observed in connexion with the yet imperfectly formed fibres of cellular tissue that are interspersed among those of the elastic tissue.

PROPER FIBROUS TISSUES.

§ 213. The mode in which cells comport themselves and combine so as to form cellular fibres has been already alluded to (§ 31, 84, 85, 87, and 131), and in the cellular tissue of certain parts the developement goes no farther than as it has been heretofore described. In others, the intercellular or connecting fibrils undergo elongation, the fusiform cells disappear, and leave proportionately long fibres behind, which are either, 1st solid, and (*a*)

* See farther on this subject in the Section that treats of Vessels. For additional information on the Elastic Tissue, see Eulenberg's "Diss. de Tela Elastica." 4to. Berlin, 1836; Müller's "Physiology;" Schwann's "Mikroscopische Untersuchungen;" and Valentin's "Repertorium."

flat, (*b*) prismatic, or (*c*) cylindrical; or, 2d, tubular or hollow and containing fluid. These fibres either lie parallel, near to one another, and form bundles or fasciculi, or they cross and interlace singly or in fasciculi, and so form simpler or more complicated textures. The cylindrical solid fibres are met with in the greater number of the soft parts of the human and animal body, either as principal or as subordinate constituent elements. With some slight modification in diameter, density, elasticity, colour, &c., they form constituents of very different systems. They exist, for example, in the fibres of the cellular substance, in those of tendons, ligaments, fibro-cartilages, contractile tissues, and muscles, which all,—in form, properties, composition and destination,—constitute different tissues.

Cellular Substance—Cellular Membrane.

§ 214. By *cellular substance* we understand the matter of which the fibres of the cellular tissues consist; by *cellular tissue*, the various compounds that result from the crossing or intertexture of these fibres. The structure, which is commonly called cellular substance, is an extremely compound body, and besides proper cellular fibres contains blood and lymphatic vessels, serous fluids, blood and lymph, fat, nerves, &c. Cellular substance is a soft, moist, glutinous, elastic, white or grey coloured and very transparent material; the peculiar delicacy of its elements gives it a certain resemblance to thick mucus. It forms cavities (areæ, areolæ) of various sizes, which are more or less completely filled with serum or fat. It seems to possess a certain degree of organic contractility, *i. e.* an inherent power, on the application of certain stimuli, of shrinking in bulk: it has, however, little ordinary sensibility. Delicate reticulations of blood-vessels and lymphatics extend in all directions and in great abundance betwixt its fibres and laminæ; it is therefore, upon occasion, apt to increase greatly in quantity, and is readily reproduced.* The branches of nerves which are visible in the cellular substance by the naked eye do not belong to it, but merely pass through it towards other organs. In consequence of the delicacy of its elements it possesses considerable powers of adhesive and capillary attraction, so that it is often seen to become rapidly and greatly distended with watery fluids from neighbouring parts. Its meshes and areolæ are more or less connected through the entire body, so that air or watery fluid permeates it readily, the watery fluid by reason of its specific gravity falling down and infiltrating the most depending parts.

* After the cellular tissue has been completely destroyed it is generally not reproduced. Witness the adhesion, as it is termed, of the scars of old deep ulcers to bones, a circumstance which is often considered as a sufficient cause for the rejection of otherwise eligible recruits for the army; and every one is acquainted with the depressed cicatrices, where there is a want of subjacent cellular tissue, which follow various sores, particularly those in which there has been sloughing of the cellular substance. Independently of ulcers, the cellular substance of some parts, as of the legs, appears to be liable to atrophy, so that the limbs become hide-bound.—See *Edin. Med. and Surg. Journ.* vol. xlvi. p. 308.—*G. G.*

§ 215. The elements of the cellular tissues are the fibres of the cellular substance, and present themselves in the guise of simple cellular fibres and perfectly rounded bands. The former constitute an extremely soft mucus-like cellular tissue; the latter a stronger fibrous cellular tissue. As these different kinds of cellular tissue serve different purposes, we distinguish, 1st, the fibrous or varicose from, 2d, the fascicular cellular tissue. The relations of the cellular tissue to the other tissues, to the different organs and systems, affords the basis of another subdivision; viz. into 1st, investing and connecting cellular tissue; and 2d, intimate or component cellular tissue.

Microscopic Examination of Cellular Substance.

§ 216. The perfectly developed cellular substance, consists of extremely fine and transparent, smooth, soft but tough, even, generally cylindrical fibres, with pale, delicate bounding lines, from $\frac{1}{1600}$ to $\frac{1}{1200}$ of a Paris line in diameter, and which rarely run singly, but commonly in fasciculi, in wavy or sinuous lines (*fig.* 19). It forms every variety of fibrous compound and tissue, viz.

1st. *Single fibres* traversing other tissues (*fig.* 73, *e*).

2d. *Parallel fibres* running either together and in contact, or separated by a gelatiniform interposed substance (*fig.* 194).

3d. *Fibres united into flat cords*, running parallel and close to one another, and either straight or sinuous (*fig.* 195, and *fig.* 19).

4th. *Simple parallel, and multilamellar parallel Membrane*—composed of fibres running parallel and close to one another in the same plane, in one or in several strata (*fig.* 49, *A*, and *fig.* 200). The dense serous and synovial membranes, and the dense cellular sheaths of the firm nervous fasciculi, for instance (*fig.* 88, 9), belong to this category.

5th. *Tissues of Cellular Substance*—(*fig.* 49, *B*, and *fig.* 197), composed by the interlacement and irregular crossings of single fibres. This tissue is met with between the fine layers of other tissues, and also in the most delicate portions of the serous membranes.

6th. *Fibrous Net of Cellular Substance.*—Isolated parallel fibres crossing and interlacing obliquely with one another (*fig.* 198). It occurs, like the simple cellular fibrous tissue, amidst finely stratified tissues, and as an envelope, of the ganglionic globules, for instance (*fig.* 89, 6).

7th. *Fibrous Grating of Cellular Substance.*—Isolated fibres crossed or interwoven at right angles (*fig.* 199). This occurs along with the fibrous rete and the irregular fibrous texture.

8th. *Tissue of Cords and Fasciculi of Cellular Substance.*—A tissue composed of bundles or cords (*fig.* 50). It occurs in lax serous membranes, in the omenta, &c.

The tissues made up of bundles and cords exhibit all the varieties of tissue formed by the simple fibres above enumerated, but it is unnecessary to specify them.

§ 217. The fibrous cellular substance frequently presents itself mingled with cells, nuclei, &c.

Investing Cellular Substance.

§ 218. The investing and uniting cellular substance, or the isolating superperipheral cellular tissue, covers the superficies of the greater number of single organs, which it isolates and yet connects, and the interspaces of which it fills up, smoothing inequalities, and giving roundness and symmetry of form. It is a material of this kind that connects the skin with the subjacent parts,—the subcutaneous cellular tissue; that contains the serous fluid which belongs to it (§ 17), and the subcutaneous fat,—fat vesicles and fat cells, which constitute something like one-twentieth of the whole weight of the body (§ 133). It forms universally larger and smaller serous cavities—areæ, areolæ.

Cellular Substance entering into the Composition of other Tissues.

§ 219. The proper constituent matter or parenchyma of organs is invariably intermingled with more or less of cellular substance, which, indeed, forms an essential element in their constitution, connecting the several particles together into a whole—the glomeruli of glandular structures into glands; the primary muscular fibres and bundles into muscles;* the primary nervous tubuli into nerves, &c.

* There does not appear to be any cellular tissue between the muscular fascicles of the heart. At least, after several observations made especially with a view to this point, it appeared to me that the fleshy part of the heart was entirely made up of its

Fibres of the Cellular Substance, Varicose Cellular Substance.

§ 220. The cellular fibre (§ 82—86), is the transition form of the cell into the filament. The fibre of the cellular substance is not, however, in every case a temporary or convertible element of this kind; it often remains stationary at this stage of its evolution, so that some tissues or parts of tissues, consist, in great measure, of a structure of this kind. It forms, for example, a delicate envelope around the finer vessels (*fig.* 102, *c*, *c*), and around the soft nerves (*fig.* 163, *c*, *d*). With the final subdivisions of these organs, the fibres of the cellular substance quit them, and form a particular rete within their meshes (*fig.* 106, *c*, *c*). Fibres of this kind are encountered in almost all the tissues, either as a soft matrix, or as a delicate investing and connecting medium.

Membranes of Cellular Substance.

§ 221. Membranes composed of cellular substance are extensively disseminated through the body. They consist either of fibres densely compacted, or of tissues of these, either by themselves, or mingled with the fibres of the cellular substance. To this category belong the serous and synovial sacs.

peculiar muscular fibres, without visible intermixture of any other tissue whatever. See "Observations on the Muscular Fibre of the Œsophagus and Heart in some of the Mammalia."—*Proc. Zool. Soc. No. LXXXI. Sept.* 1839.—*G. G.*

1. *Serous Membranes.*

§ 222. These form shut sacs, lining all the internal close cavities of the body, and investing in uninterrupted continuity the organs included within them. The free surface is covered with a tessellated epithelium, which in the ventricles of the brain alone presents ciliæ. The following are the membranes which are accounted serous: —

The inner lamina of the dura mater of the brain and spinal cord; the tunica arachnoidea of the same parts; the pia mater or vascular membrane of the same parts, the lining membrane of the ventricles included; the pleuræ; the pericardium; the peritoneum, and its process the tunica vaginalis testis; in the fœtus, the amnion. The allantois seems to stand in the middle between the serous and the mucous membranes; it is, however, an offset from a mucous membrane, the bladder of the fœtus.

The great serous sacs now enumerated agree essentially in structure and function with the smaller cavities of the loose investing or interstitial cellular substance, and only differ from these in their greater size, and in having their free surfaces overspread with a tessellated epithelium.

The free surface is always smooth and polished, and lubricated by a serous fluid, by which all friction between contiguous parts, and the coalition of these with one another are prevented.

2. *Synovial Membranes.*

§ 223. The synovial, like the serous membranes form shut sacs, and perform similar offices. They are distinguished from these principally in their composition of several layers of immediately connected cellular filaments, and in their transudation of a serous fluid that is thicker and much richer in albumen than ordinary serum; this is the synovia or joint oil, the necessity for the greater consistency of which is obvious.

The synovial sacs either indue and close in the cartilage-covered ends of bones, when they are called *articular synovial capsules*, or they lie as simple bladders between tendons and projecting parts of bones, between muscles, and even between the skin and subjacent hard parts, when they are entitled *bursæ mucosæ*. All the tendons, too, that pursue their course to their points of attachment through long grooves of bones, or that pass round prominent parts of these as a cord does over a pulley, are provided with elongated synovial sacs, denominated *synovial sheaths*.

§ 224 *a. Articular Capsules.*—Suppose a spherical shut synovial sac to be pushed between the articular extremities of two bones, and to cohere with the entire cartilaginous surface of each to the very edges; suppose the bones now approximated till the inner aspects of the synovial investment of the cartilages met, and the sac to be partially filled with synovia, the outer free portion of the synovial sac would then surround the joint like a girdle. Let this free girdle be farther supposed to be covered externally with a fine tendinous or ligamentous membrane of corresponding size and form, and this to adhere by its edges to the periosteum in the circle of the articular cartilages, and a complete idea will be obtained of an articular capsule. It is evident, therefore, that the articular cartilages are never immediately in contact, but that the inner smooth surface of the synovial membrane, separated by a thin stratum of synovia, is opposed to itself, an arrangement by which motion is greatly facilitated, and the cartilages are protected from injury so long as the lubricating fluid is poured out in sufficient quantity and of proper quality. The outer fibrous or ligamentous girdle strengthens the free circular portion of the capsule. As the articular capsules are completely closed, and the air of the atmosphere can in no way enter them, an extremity, the muscles of which were completely relaxed, would not fall away from the fixed part with which it was articulated,—the anterior extremity, for instance, from the glenoid cavity of the scapula,—so long as the weight of the extremity or the dissevering force did not exceed a certain amount, easily determinable and bearing relation to the extent of the articular surfaces.*

Synovial capsules are frequently surrounded with a larger or smaller quantity of a yellow-coloured fat. The synovia is a viscid stringy fluid, perfectly adapted to lubricate opposed surfaces. It

* This of course results from the pressure of the atmosphere, which acts with a force equal to fifteen pounds upon every square inch of surface. Suppose the diameter of two contingent articular cartilages to be = 2 in. and the surface therefore to be = 2·96 square inches ; then under a mean barometric pressure of 29 inches, a power = 2·96 × 15 = 44·4 lbs. would be required to separate the articular head from the socket.

consists of serum with from six to ten per cent of additional albumen. It shews alkaline reaction.

§ 225. *b. Synovial Sheaths of Tendons.*—Whenever tendons play upon bones as cords do upon pullies, they are found provided with a double synovial sheath, being inclosed immediately within a synovial tube which is then reflected upon itself, so as to line the groove within which the motion takes place, in the same manner as the pleura and peritoneum are reflected around the various viscera of the thorax and abdomen. These synovial sheaths are so loose at the extremities as to oppose no impediment to the freest motions. They are bedewed with a synovial fluid of the same nature as that of the articulations.

§ 226. *c. Articular Bursæ.*—These are sacculate or bladder-like synovial membranes, which commonly occur in the vicinity of joints and points of attachment of tendons, being placed betwixt these and a cartilage-covered and generally projecting portion of the bone. They contain the same kind of synovia as the articular capsules, and serve to facilitate motion and to spare the tendons when they play over elevations of bones.

§ 227. *d. Subcutaneous Bursæ.*—In those places where the skin passes immediately over projecting points of bone, as the elbow, tuberosity of the tibia, &c., an interposed bursa is always found, which facilitates the gliding of the integument over the hard projection, and also serves as a pad or cushion to diffuse the pressure.

§ 228. To the membranes composed of cellular substance appertain the cellular sheaths of the muscles, the outer coats of the blood and lymph vessels, and of the ducts of glands; the inner coat also of the blood-vessels and lymphatics comes under the same head, unless it be assigned to the peculiar class of serous tissues, inasmuch as it is free, forms a closed, however much elongated and extensively branched cavity, and is covered with a tessellated epithelium.

§ 229. The cellular substance of the fœtus, which consists, in great part, of cellular fibres, yields no gelatine by boiling, like the cellular substance of older animals, and Schwann has observed that it is only the interjacent cytoblastema or hyaline substance that is dissolved in boiling water, not the cellular fibres themselves. This observation reminds us of the insolubility of the fœtal blood-disc by acetic acid. The division of the cellular fibre into a plurality of fibrils, which Schwann regards as constant, I have myself seen so seldom distinctly, that I am forced to look upon it as among the number of varieties.

TENDON.

Tendinous Fibre.

§ 230. The tendinous fibre is distinguished from the cellular fibre only by greater consistency and rigidity, and, in connexion with these qualities, by the maintenance of its natural sinuosities and crispings, by its greater degree of opacity and of regularity in its course, and the silky appearance which ensues from this; farther, by a more invariable parallelism of the fibres to one another, upon which depends the pearly lustre of tendons.

The tendons have very minute blood-vessels,* which course between and parallel with the fibrous bundles, forming a wide-meshed rete. Tendons seem to have but a very limited supply of nerves.

§ 231. The tendons in the fœtus are formed at even an earlier period than the cellular substance; but in the same manner as it, the cellular fibres destined to form tendons collecting into rounded bundles soon after their formation. At first they are more transparent and of a dull grey, not glistening like silk or mother of pearl. Even in the fœtus the fibres of tendon are less separated by any intervening or connecting matter than the fibres of the cellular substance; they are, therefore, more immediately and intimately in contact. From the one to the other, however, there is frequently a gradual transition to be observed, so that even in the adult doubtful intermediate forms of every degree of proximity to the one or the other are encountered. In the long tendons and firm tendinous membranes or aponeuroses, the fibres are straighter than elsewhere even in the fœtus, but in other places they are more plentifully mixed with cellular substance and more sinuous (*fig.* 51, *b*, *c*).

§ 232. *Chemical Examination of Tendinous Fibre.*—Chemically considered, the tendons bear a

* Some observations on the Blood-vessels of Tendinous Tissue have recently been made by Mr. Paget.—See *Lond. Med. Gazette*, vol. xxiv. p. 562.

In the museum at St. Bartholomew's Hospital there is an excellent injection of these vessels made many years ago with mercury by Mr. Wormald; and Professor Sharpey shewed me some injections of the vessels of tendon when he was engaged as a Lecturer on Anatomy at Edinburgh.—*G. G.*

strong analogy to the cellular substance. Those of the fœtus yield little gelatine, whilst those of the adult are entirely dissolved into gelatine by boiling. They contain about 60 per cent of water, and when dry are brown, transparent, and more brittle than dry elastic tissue.

Tendinous Tissue.

§ 233. The tendinous fibre unites in general into bundles and cords, and forms fascicular tissues more frequently than fibrous tissues. The crossings of fasciculi are more readily seen in tendons than in formations of the cellular substance, in consequence of their higher reflecting power. In the long tendons the fibres lie parallel; in the tendinous sheaths or aponeuroses, the fibres in bundles are mostly crossed and intricated. The tendinous tissue forms, 1st, Tendons of muscles, and these are either (*a*) long and rounded,—proper tendons or sinews which belong mostly to the extremities; or (*b*) broad and membraniform,—tendinous expansions, aponeuroses; 2d, Tendinous sheaths or fasciæ; and 3d, Fibrous membranes, and tendinous bands or ligaments.

Long Tendons, Sinews.

§ 234. The tendons are the fibrous tissues connected with muscles, which generally serve them as means of origin and insertion, though in many cases the tendons run through or along the entire course of muscles. In the recent state they are sericeous or silky, of a bluish, yellowish, or reddish white, iridescent, extremely strong, but very little elastic; their fibres are generally parallel to the axis of the muscle; in the penniform and semi-penniform muscles they run obliquely; in form they are cylindrical or flat in different degrees, and conical on the muscles; where they pass over bones or hard parts they are defended by synovial sheaths or bursæ; when they pass around a projecting process of bone, as a trochlea, they are sometimes seen converted into a substance having the texture and appearance of fibrous cartilage: in such situations they are always bound down and confined in their places by tendinous or ligamentous sheaths.

Where the tendon meets the muscle, the primary muscular bundle is conically pointed, and the fine tendinous fibres arise from the entire cone (*fig.* 31, *a*, 1). At the point where the tendon is attached to the bone, it is generally somewhat expanded; the immediate attachment is the periosteum.

Tendons, along with bones, cartilages, ligaments, &c., belong to the passive organs of motion, and serve as admirable means of transmitting the inherent contractile powers of the muscles to a distance. The aponeuroses or tendinous sheaths again supply points of origin to the long tendons and muscular fibres, and, at the same time, bind down in their places and isolate the bellies of muscles and the tendons that proceed from them.

Tendinous Expansions; Aponeuroses; Fasciæ.

§ 235. The membraniform tendons or aponeuroses often form the tendinous continuations of flat or membraniform muscles, and cover at once and enclose other organs. They are either entirely tendinous, and their fasciculi run in one and the same direction,—the tendons of the external and internal oblique muscles of the abdomen, for example; or the component fasciculi cross in different senses,—the tendinous portion of the diaphragm, for instance; or, otherwise, they contain or are mixed with elastic tissue,—the aponeurosis of the external oblique, to wit. These tendinous expansions are pierced in numerous places by vessels and nerves. They serve, like the cordiform tendons of the long muscles, for the transmission of motion; they assist in supporting the organs they surround,—the abdominal viscera, in particular, and compress these under the contractions of the appertaining muscles, by which they become powerful means aiding in many important processes.

Tendinous Muscular Sheaths.

§ 236. Over the muscular sheaths of cellular substance, especially in the extremities, we find particular tendinous sheaths which surround the individual muscles in the shape of dense networks of fibrous fasciculi, and externally compose a general sheath including the muscles of the entire extremity. The fasciæ of the fore-arm, thigh, and leg, afford examples of this structure. These fibrous sheaths supply points of origin to the muscles, keep them in their places, and support them in their more violent exertions. With a view of rendering these sheaths tense we even see particular muscles either attached to them entirely or sending off tendinous processes to them: the great fascia of the thigh has its tensor muscle; the sheath of the fore-arm has the strong offset from the biceps brachialis to brace it up. These tendinous sheaths are also attached to the bones, and sometimes they pass over into tendons and aponeuroses; they likewise surround other organs, and attach and isolate these from neighbouring parts,—the muscles from one another, the muscles from blood-vessels, nerves, &c.

Tendinous Membranes strengthening the Serous and Synovial Membranes.

§ 237. The free lying portions of the serous and synovial membranes are upon occasion supported and strengthened by means of fine tendinous expansions, which generally consist of a delicate reticulation of fibrous bundles, so intimately connected with the membranes that they are often scarcely to be separated from them. The outer layers of the pericardium, of the articular capsules and tendinous sheaths, of the linea alba abdominis, which is remarkably developed in the horse, are examples of the structure in question.

Peculiar Fibrous Membranes.

§ 238. Different organs are surrounded by tough membranes, generally composed of an admixture of tendinous fibres and elastic tissue, and having, consequently, a pale yellow tint, and little or none of the pearly lustre of tendon. Sometimes the investment seems to consist of tendinous fibres entirely, and then it shews the nacreous lustre; though in other instances, the composition being the same, but the intrication of fibres greater, it is dull and lustreless. Of this description are the fibrous membranes that surround the erectile organs, at the same time that they penetrate their substance in all directions as a powerful network. We have examples of the structure in the fibrous membrane of the penis, clitoris, and spleen. The breast in the human female, and the udder and dug in the lower animal are also surrounded by a network, more or less close, of the same tissue, connected with the investing fibrous membrane, and suspending the erectile vessels in its meshes. The excessive dilatation of many organs is guarded against by strong investing proper membranes. The dura mater, the tunica albuginea testis et ovarii, the tunica sclerotica oculi, the periosteum and the ligamentous articular sheaths, which in many places surround such compound articulations as those of the wrist and tarsus, belong to this category. These fibrous membranes form a medium of transition to the ligaments properly so called.

Fibrous Bands; Ligaments.

§ 239. The fibrous bands or ligaments of the articulations, and of the cartilaginous and fibro-cartilaginous junctures of the bones are, on the one hand, closely allied to tendons; on the other, to fibro-cartilages: they consist of fibres stronger, more disposed to crisp, and which, though connected parallel with each other, shew less of the silky or pearly lustre than tendons; the ligaments are also of a yellower hue than the tendons. They are partly to be viewed, like the tendinous corroborating sheaths of the articular capsules, as extensions or productions of the periosteum over joints; some, however, are actually included in the fibrous capsule, the transverse ligaments of the tarsus and carpus, for example, the round ligament of the hip, and the crucial ligaments of the knee joint; the latter proceed from one bone to another athwart the joint, and are surrounded by a tubular production of the synovial capsule. Besides the round and cruciate ligaments just mentioned, we have lateral ligaments, straight or perpendicular and oblique ligaments, annular ligaments, trochlear ligaments, &c., particularised. In shape they are cylindrical, prismatic or flat, elongated or annular.

The round ligament of the hip-joint is cylindrical, and runs from the middle of the lower edge of the acetabulum to the pit in the head of the thigh bone. The crucial ligaments of the knee belong to the prismatic order, and connect the femur with the tibia in the middle of their opposed articular surfaces, crossing each other at an acute angle. The lateral ligaments are for the most part flat, and connect the bones externally, and in such a way that but a very limited degree of motion is admissible save in one direction; general investing ligaments, as those of the carpus and tarsus, only allow a slight amount of gliding of the articular surfaces one upon the other; the annular ligaments surround the neck of a bone so as to form a kind of pivot-joint.

The ligaments are in a great measure convertible into gelatine by boiling, like the tendons; but they dissolve less readily than these. They are among the toughest, the strongest structures in the body; they are the rather adapted for the purposes they serve as they possess some slight elasticity; they are considerably more elastic than tendons.

Fibrous or Fibro-cartilage.

§ 240. Fibro-cartilage, when its texture and general properties are considered, seems to occupy a place intermediate between cartilage and ligament. It consists in general of dense intercrossing fibres (*fig.* 53, A), but in some cases there is beyond all doubt a considerable intermixture of elastic tissue, when the structure assimilates itself with reticular cartilage. It is highly elastic, of a yellowish white colour, and in general obviously fibrous. It forms the intermediate substance in all the articulations by synchondrosis, uniting the bones without the intervention of capsules by means of a succession of concentric laminæ of fibres crossing one another obliquely in opposite directions. All the vertebræ, save the atlas, are connected in this way, as are also the bones of the pelvis with the sacrum and with one another.

CONTRACTILE FIBRE—CONTRACTILE TISSUE.

§ 241. Beneath the skin, especially in those places where, under the influence of cold and other peculiar stimuli, a notable corrugation and thickening are obvious, certain fibres may be distinguished, different from the round fibres hitherto described, in as much as they are of somewhat greater diameter, of a redder colour, and possess a peculiar kind of transparency. These fibres are, however, met with not only immediately beneath the skin, but in its substance, and either singly or united into cords or bundles. They run more or less parallel and near to one another (*fig.* 73, *a*, *b*, from the scrotum, where they are interwoven with transverse fibres and bundles of cellular substance, *c*); or they form plexuses which resemble the terminal plexuses of the nerves (*fig.* 71, *a*, and *fig.* 72, *a*), with this difference, that the individual fibres interlace and amalgamate, the several bundles not merely interchanging primary fibres without any real blending as the nerves do (*figs.* 91, 95, and 106).

The inherent contractile power of these fibres and their general structure place them as transition-forms from the passive round fibre to the active fibre of muscle. In the skin of the hog they measure from the $\frac{1}{100}$th to the $\frac{1}{60}$th of a Paris line in diameter.

The contractile tissue, now alluded to, on the application of cold, and under the influence of mental emotions,—rage, terror, &c., produces the appearance called goose-flesh, and causes the hair to become erected. In some limited portions of the integument the corrugation effected is still more remarkable; the nipple, for instance, becomes hard and in some sort erected by its means; the scrotum too becomes as hard as a ball, and greatly shrunk in size, by which the testes are forced up towards the inguinal rings, and as actively compressed as they are by the cremaster muscles. This contractile tissue enters as an element into the constitution of the penis and clitoris, probably also of the blood and lymph-vessels, and of the excretory ducts of glands. The motions of the iris, producing contraction and dilatation of the pupil, seem likewise to depend on the agency of contractile tissue, light acting as the appropriate stimulus here; but this is a point upon which information is attainable with greater difficulty than as regards the common integument.

MUSCLE—MUSCULAR TISSUE.

§ 242. The flesh or muscles of animals are of a pale or darker red colour, and consist of a multitude of fibres and fasciculi of fibres, intimately connected and running parallel to one another. Muscles are the instruments of active motion, voluntary as well as involuntary, through the whole series of the animal creation, and this they are in consequence of their inherent power of alternate contraction and relaxation. As means of voluntary motion we see the muscles arranged around the trunk and extremities, which they use as levers for the execution of the behests of the will. As means of involuntary motion we see them forming the middle tunic or the mass of various hollow or tubular organs, the diameters of which they diminish by contracting, and which by relaxing they suffer again to be distended.

The muscles are generally divided into (1) organic, (2) animal, and (3) mixed; in other words, into such as belong to the organic life, such as belong to the animal life, and such as are of a mixed nature. The muscles of the organic life contract and do their office involuntarily and without the consciousness of the animal: the muscular substance of the heart, the muscular parietes of the stomach and bowels, are muscles of the organic life. Muscles of the animal life are under the control of the will and only act to execute its purposes: the muscles of the extremities all belong to the animal life. Muscles having a mixed character execute certain motions involuntarily and unconsciously to the individual, and yet are under the influence of the will to perform motions for other purposes, or to execute the same motions more rapidly or more slowly; of this kind are the muscles of respiration, which carry on the process of breathing during sleep, that produce involuntary sneezing, coughing, crying, &c., and that yet under the influence of the will elicit the voice, &c. The muscles are very plentifully supplied with nerves of motion, and but scantily with nerves of sensation; they are therefore highly irritable, but by no means very sensitive.

Organic or Involuntary Muscles.

§ 243. The muscles of organic life are in connexion with the organic or ganglionic system of nerves, and are, therefore, independently of consciousness and will, excited to certain determinate actions, which here are strictly rhythmical and interchanged with cessations from action; they are spasmodic in some sort or irregular in their periods of activity and relaxation. The muscles of this class are for the most part pale in colour, finely fibrous, soft, transparent, deeply situated in the body, and moderately supplied with soft, greyish-coloured nerves, mostly of the motory order, and with blood-vessels, both of these coursing in general between the fibres and fasciculi that compose them. The organic muscles are more susceptible of mechanical than of chemical stimuli, and are not connected with tendons like the muscles of the animal life.

§ 244. Examined microscopically, the organic muscles are found in general to consist of delicate yellowish red coloured transparent fibres, with very faint boundaries, which, like the round fibres especially, though singly cylindrical, are flat or prismatic when united into bundles, the pressure of the several fibres giving them this figure. The fibres seldom run stretched out, and united into round bundles as in *fig.* 75 A, *a*, *a*; they are far more commonly bent sinuously (B), or are even crimped (*c*) and combined into flat cords. In a higher degree of rigidity they are often irregular and shortly bent, by which they acquire the peculiar angular character which H. R. Ficinus* has so faithfully represented in his figures. The fibres and bundles open and close under the mucous membranes in the manner of nervous plexuses, and form meshes in which mucous glands lie imbedded, or they surround these like loops. The muscular bundles lying in the same plane form muscular membranes, which are

* "Diss. de Fibræ Muscularis Forma et Structura." 4to. Lips. 1836.

Dr. Baly has given some good observations on the organic muscular fibre, and an accurate delineation of the corpuscles observable in the flat fibres or filaments. See Translation of Müller's "Physiology," 1838, plate 2, fig. 9. The corpuscles, according to my observations, are often absent, though the riband-like filaments may be very distinct.—See *Proc. Zool. Soc.*, *Sept.* 10, 1839.—*G. G.*

disposed one over the other in two or three layers, the component bundles of each always crossing those of the other obliquely or at right angles, thus forming networks or gratings (*fig.* 85, and 76, A).

In this manner appear for the most part the fibres of the muscular coat of the œsophagus, near the stomach; of the stomach itself, and the intestinal canal, with its immediately derived ducts, the hepatic and pancreatic ducts; of the urinary bladder and the ureters; of the vesiculæ seminales and vasa deferentia; of the trachea and bronchi; and of the middle coat of the veins and lymphatics. Frequently, however, the fibres are less divided and the fasciculi more distinctly granular (*fig.* 76, B); sometimes, indeed, they are decidedly granular, as in the uterus of the cow (*fig.* 74): from the ends of the torn granular fibrous bundle (A) project fibres of cellular substance, which, running betwixt the granular fibres, appear to be connected with the granules; at least, the granules remain hanging to the apparently branched fibres after operating on the bundles by alternately squirting water on them and pressing them gently (*fig.* 74, B).*

Although the organic muscular fibres in general appear so regularly granular (§ 251), this is seldom the case with the fibres of vessels which, as Professor Valentin† has already shewn, resemble the larger examples of the contractile round fibre so much, that it is still doubtful whether they ought not rather

* This appearance of the uterine muscles I have, indeed, only seen very distinctly once, but then it was in sections from different parts of the organ.

† "Repertorium," 1837. S. 242.

to be assigned to the contractile than to the proper muscular tissue.

§ 245. An isolated, azygous, organic muscle, partly covered by the skin only, is found in the solidungula under the urethra. This retractor of the penis possesses the precise texture and colour of the organic muscles: it is a prolongation of the muscles of the rectum to the glans penis.

Passage of the Organic into the Animal Muscles.

§ 246. No voluntary muscle without transverse streaks is known;* but some muscles that have transverse striæ, nevertheless, from standing in a certain relationship to the animal as well as the organic system, assimilate in their mode of action with the involuntary muscles. To this head belong the muscular substance of the heart and that of the œsophagus near to its ventricular end.† The deep

* Many fibres of voluntary muscle are without these streaks. Such fibres appear to be composed simply of irregular granular matter inclosed in a sheath (*sarcolemma*) without the least appearance of primitive fibrils. In the pectoral muscle of the long-eared bat (*Plecotus auritus*, Geoff.), examined immediately after death, almost all the fibres were of this character. They measured from $\frac{1}{888}$th to $\frac{1}{571}$st of an English inch in diameter.—*G. G.*

† The muscular fibre of animal life invests the gullet much nearer to the stomach in many brutes than in the human subject; and there is also a remarkable difference in this respect in several of the mammalia. In some of the rodentia, and in the sloth bear (*Ursus labiatus*, Blainv.), the muscular fibre of animal life extends to the cardia, and in some mammals may be found beyond the termination of the gullet. In the quadrumana, in the horse, in the lion, and many other species of felis, the muscular fibre of animal life does not extend nearly to the end of the gullet. The subject is deserving of further inquiry.

red muscles of the heart consist of fine transversely streaked, and often waved, primary fasciculi, from the $\frac{1}{100}$th to the $\frac{1}{80}$th of a line in diameter, which divide again and again like the prongs of a fork, and combine in the manner of a net (*fig.* 84). These muscular fasciculi contract and relax without intermission, rhythmically and powerfully, from the commencement of life in the embryo, to its end, at the age it may be of a hundred years, forcing the

Professor Müller assures us that "the third act of deglutition is quite involuntary, being performed by the muscular fibres of the œsophagus, which are not in the slightest degree capable of voluntary motion." However true this may be as regards man, it is probably different in those animals which have the entire muscular sheath of the gullet composed of fibres identical in all respects with the fibres of the known muscles of voluntary motion.

The muscular structure of the heart appears to me to be altogether peculiar; not to mention other points, the comparatively small size of its primary fascicles, and the absence of intervening filaments of cellular tissue, serve to distinguish the muscular fibres of the heart from the fibres of the muscles of voluntary motion. See "Observations on the Muscular Fibres of the Œsophagus and Heart in some of the Mammalia."—*Proceedings of the Zoological Society,* part vii. p. 124, *et seq.*

I subjoin from my notes measurements of the size of the primary fascicles of the heart in several mammals. Though the size of the fascicles differs considerably, it is uniformly smaller than that of the primary fascicles of the muscles of voluntary motion. But in very young animals this difference is often scarcely appreciable; thus, in a kitten a few days old, the primary fascicles of the pectoral muscle were as small as those of the heart. The fascicles of the auricles were generally found to be much smaller than the fascicles of the ventricles; but there were some exceptions: in the bearded sheep (*Ovis Tragelaphus*) and the fox, there was scarcely any difference in the size of the fascicles of the auricles and ventricles. The following measurements are expressed in fractions of an English inch; the animals, blood poured into the cavities of the heart in its determinate round, and proving the efficient cause of the pulse. The number of contractions of the heart in the adult human subject amounts, on an

unless noted to the contrary, were adults which had been dead several hours before the hearts were examined:—

Table shewing the Diameter of the Primary Fascicles in the Heart of some of the Mammalia.

Name of Animal.	Part from which Fasciculi were measured.	Diameter of Fasciculi.
Cercopithecus griseo-viridis, Desm.	Ventricles	$\frac{1}{1333}$ to $\frac{1}{1000}$
Cercopithecus sabæus, Desm.......	Ditto	ditto ... ditto
Cercopithecus Æthiops, Geoff. ...	Ditto	ditto ... ditto
Macacus Rhesus, Desm...........	Ditto	ditto ... ditto
Vespertilio noctula, Schreb.	Ventricles	$\frac{1}{2000}$ ... $\frac{1}{1000}$
Plecotus auritus, Geoff.	Right ventricle	$\frac{1}{1600}$ ... $\frac{1}{800}$
Ursus labiatus, Blainv...............	Left ventricle	$\frac{1}{2000}$ ... $\frac{1}{1000}$
Canis Vulpes, Linn.	Ventricles and auricles	$\frac{1}{1666}$ ... $\frac{1}{1333}$
Canis familiaris, Linn. (12 days old)	Ventricles	$\frac{1}{2666}$ ... $\frac{1}{2000}$
Canis argentatus, Desm.............	Ditto	$\frac{1}{1333}$ ... $\frac{1}{1000}$
Felis Leo, Linn. ($\frac{2}{3}$ds grown)......	Ditto	$\frac{1}{2000}$ ... $\frac{1}{1777}$
Felis concolor, Linn.	Right ventricle	$\frac{1}{2000}$ ... $\frac{1}{1333}$
	Left auricle	$\frac{1}{4000}$ ... $\frac{1}{2000}$
Felis Leopardus, Linn.	Left ventricle	$\frac{1}{2666}$ ... $\frac{1}{700}$
Felis cervaria, Temm.................	Ventricles	$\frac{1}{2000}$ ... $\frac{1}{800}$
Felis Caracal, Gmel.	Left ventricle	$\frac{1}{1600}$ ... $\frac{1}{1000}$
Lutra vulgaris, Erxl.	Ventricles	$\frac{1}{2000}$ ... $\frac{1}{1143}$
Equus Caballus, Linn.	Ditto	$\frac{1}{2000}$ ... $\frac{1}{666}$
Antilope Bubalis, Pall............	Ventricles	$\frac{1}{1600}$ ... $\frac{1}{1000}$
	Auricles	$\frac{1}{4000}$ ... $\frac{1}{2000}$
Ovis Tragelaphus, Desm..........	Auricles and ventricles	$\frac{1}{1777}$ ... $\frac{1}{1143}$
Sciurus vulgaris, Linn.	Left ventricle	$\frac{1}{2000}$ ... $\frac{1}{1000}$
Cavia Cobaya, Gmel.	Ventricles	$\frac{1}{1333}$ ... $\frac{1}{800}$
	Auricles	$\frac{1}{2400}$ ... $\frac{1}{1714}$
Lepus timidus, Linn.	Left ventricle	$\frac{1}{2000}$ ... $\frac{1}{800}$

G. G.

average, to about 108,000 per diem; in the horse and ox, the number is but about 54,720, little more than one-half.

The muscular compages of the œsophagus transmit the bolus of food and the drink delivered to them by the mouth, independently of the will, and in some sort of consciousness, to the stomach. The muscular fasciculi here are of a less intense red colour than those of the heart, but so far as the striæ are of a deeper hue, they are still streaked transversely in the same manner as the muscles of voluntary motion. In the immediate vicinity of the stomach, the transverse striæ diminish in distinctness, and the colour in intensity, and then they disappear entirely, when the primary fasciculi, especially in the graminivorous tribes, are less widely separated, and now appear to consist of granules from the $\frac{1}{400}$th to the $\frac{1}{300}$th of a line in diameter, united into difficultly separable granular fibres.

Animal or Voluntary Muscles.

§ 247. These are by so much the more deeply coloured, and their component fasciculi by so much the finer and firmer, the stronger, older, and better bred the animal is in which they are examined, and the more they are exercised. The muscles in general, therefore, commonly appear of a dark brown in aged animals; those only that are rarely called into action, those of the skin, for instance, retain the brighter hue which they have in earlier life. The muscles of animal life are less transparent than those of organic life; but they are just as soft and moist, and after death easily lacerable; during life, however, they are even stronger than the sinews with which they are generally connected at their extremities, for under great efforts these, or their fibrous attachments to the periosteum, rather give way than the muscular flesh. The voluntary are more readily separable into secondary and primary fasciculi than the organic muscles. They are plentifully supplied with cerebral and spinal nerves, and they consequently come under the dominion of the will. Their component fasciculi seldom cross, but lie parallel to one another and in intimate union.

§ 248. *Microscopic Examination of the Animal Muscles.*—The finest or elementary portion of the voluntary muscle, is a delicate granular fibre, called *filum* by Muys and Prochaska, *fibrilla* by De Heyde, *fasciculus carneus primitivus* by Fontana, and by recent anatomists generally, the *primary muscular fibre.* Muys, and after him, Home and Bauer, represented this as an articulated cylinder, or prism with rounded edges, made up of shorter cylinders with rounded edges, in apposition by their bases, and under the influence of maceration becoming resolved into granules. The granules or members of the primary muscular fibre are from the $\frac{1}{700}$th to the $\frac{1}{400}$th of a line in diameter. From fifteen to twenty (according to Muys eighteen, and to De Heyde thirteen) of the primary fibres united parallel to one another, go to the formation of the finest or primary muscular fasciculus. The inquiries of Schwann, Ficinus, and the writer, have confirmed the general accuracy of these conclusions.*

* According to my own measurements, the primary muscular fasciculi of the horse are $\frac{1}{44}$th, those of the hog from $\frac{1}{45}$th to $\frac{1}{20}$th, and the primary granules from $\frac{1}{500}$th to $\frac{1}{400}$th of a line

The granules of the primary fibres appear elliptical in the relaxed muscle, their longer diameter then corresponding with the long axis of the fibre (*fig*. 82, *c*, 1); but during the action of the muscle they become flattened pomegranate-wise on their contingent surfaces (*fig*. 82, 2). The granular appearance of the primary fibres seems now to depend, even in organic muscles, on very short sinuous bendings (*fig*. 82, 3).

The primary fasciculi of flabby muscles, as they are found, for example, in the bodies of those who have died of lingering diseases, once the cadaveric rigidity has passed, exhibit their primary fibres superficially more distinct, and they therefore generally appear longitudinally streaked (*fig*. 81, 1, 2, 3; *fig*. 82, A.) Upon the torn ends of portions of such muscles, the fibres often stand out irregularly notched or toothed (*fig*. 81, 3). In the middle of the primary fasciculus again, an amorphous hyaline substance seems often to be contained, enclosed round about by the primary fibres (*fig*. 81, 2, *fig*. 79, 1, *c*).* Longitudinally streaked primary fas-

in diameter. In the diameter of the primary fasciculi from the masseter of the horse, I counted seventeen primary fibres. The primary fasciculi of the heart in the horse, which measured $\frac{1}{80}$th of a line in diameter, contained no more than from 5 to 7 primary fibres.

[The primitive fasciculi differ in magnitude considerably in different classes and genera of animals, and in the same muscle of the same animal. See Mr. Bowman's admeasurements in his "Observations on the Minute Structure and Movements of Voluntary Muscle."—*Phil. Trans.* 1840, part ii. p. 460. — *G. G.*]

* Mr. Skey describes the fibre (primitive fasciculus) as a hollow tube filled with a glutinous semitransparent substance.—*Phil. Trans.* 1837, part ii. p. 377.—*G. G.*

ciculi present at the same time broad transverse striæ, by which they appear to be sinuously bent (*fig.* 81, 3); occasionally they are indeed bent sinuously or in short zig-zags; or broadish transverse wrinkles present themselves more or less regularly; this last appearance is well seen in the muscle of the living frog in a state of action, the wrinkles being wavy and vermiform, or even distinctly zig-zagged.

If the granules of the associated primary fibres present themselves arranged in transverse rows, and the common transverse connecting lines become forked in consequence, so that the spheroidal granules project in higher relief along the contracted primary fasciculi (*fig.* 82, B,) the fasciculi then appear more or less regularly striated transversely (*fig.* 77, *fig.* 78, *a*). These relations appear not to obtain beyond the surface of the primary fasciculi; at all events, the appearances in the deeper bundles are so far modified, that the cross-streaking seems frequently to depend on the presence of a wrinkled fascicular sheath; for, when the more superficial fibres chance to be removed, and the deeper ones exposed, these appear cylindrical, and the bundle at the part is longitudinally streaked, (*fig.* 78, *b*, *c*, where the longitudinal streaks appear through gaps, as it were, of an external envelope). At the extremity of a torn fasciculus, too, the peripheral fibres often appear so distinctly marked off from the internal and more pulpy substance (*fig.* 91, 1, *b*), that the existence of a more compact transversely streaked sheath can scarcely be called

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in question.* For the accuracy of this view of the matter, the observation of fibres wound spirally about the primary muscular fasciculi of the dog (*fig.* 79, 2, 3, 4) is a farther and strong assurance; so also is the observation of Professor Valentin, to which *fig.* 80 bears reference. The suspected sheath I believe to consist decidedly of granular fibres, which may, however, by possibility, be separable in two directions, viz. transversely and longitudinally, according as the union of the neutral connecting medium of the granules in the peripheral layer is more intimate in the long or in the transverse axis of the fasciculi. Every trace of granules disappears from the animal muscles, even after boiling, under the action of oil of turpentine continued for a day or two (*fig.* 75, D).

§ 249. The import of the convoluted fibres which I have met with included in the fasciculi of some of the muscles of the horse, is unknown to me (*fig.* 83). I have seen these fibres quite as distinctly, though perhaps not with quite so hard an outline as they exhibit in the figure. I am not aware that others have observed any thing of the same kind.

§ 250. I take the opportunity of noting the following observation here on account of its singularity:

In a portion of muscle from the hind leg of a horse I found an immense number of crescentic or half-moon shaped bodies, from $\frac{1}{133}$d to $\frac{1}{100}$th of a

* Mr. Bowman considers that the sheath is not in any way concerned in the production of the transverse striæ.—*Loc. Cit.* p. 475.—*G. G.*

line in length, with rounded heads, centrally raised and blunt pointed tails. These bodies were only discovered thirty hours after the death of the animal: they exhibited no signs of life or of internal organisation.*

When the muscles pass into other structures their fasciculi become elliptically, parabolically, or conically pointed. The appearance they present under the mucous membrane of the tongue is represented in *fig.* 86, *a*, *a*. The tendinous bundles arise at different angles or parallel from the entire rounded or conical terminal surfaces of the fasciculi (*fig.* 51, *a*, 1).

Origin and Evolution of the Animal Muscles in the Embryo.

§ 251. The muscles in the embryo consist at first of nucleoli and cytoblasts, and form a finely granular substance; from this arise transparent embryonic cells which arrange themselves as fibres, the somewhat flattened cells coming together much in the same way as the blood-discs do when they form piles or columns (vide *fig.* 8). A single rank of cells of this kind by and by becomes a primary fasciculus; the rounded, granular edges of the cells do not appear to range with absolute regularity; the primary fasciculus, which is still granular ex-

* Some short time ago Professor Valentin discovered the ova of Entozoa in the spinal canal of a fœtal calf about six inches long. These ova were ovate; on the extremity they were furnished with a cover, and internally contained a germinal vesicle amidst a quantity of granular matter. In diameter they were to the blood-discs of the fœtus as 17 is to 1.

ternally, becomes more cylindrical and more transparent; it appears, particularly after the action of acetic acid, divided into compartments like a jointed conferva or the pod of the tamarind. In each compartment lies a granular nucleus, at first in the shape of a short cylinder, the axis of which accords with that of the fasciculus; at a later period the nucleus becomes rounder, flattened, smaller, and separated from others by greater interspaces, whilst the septa disappear: at this time the nucleus is completely flat and elliptical, and the great diameter lies in the direction of the length of the fasciculus, but rarely concentric with this. The walls of the cell only slightly surpass the lateral walls of the nucleus, which now consists entirely of granules, but with a still perceptible nucleolus. The muscular fasciculus not unfrequently now appears flat, and, like the nucleus, granular throughout; and the granules, it is worthy of observation, are arranged betwixt the nuclei in the apparently or virtually flat fasciculi, more longitudinally at first, but more transversely when the fasciculi are farther advanced. From four to eight of these granules lie in the transverse diameter of the fasciculi. It is along with the evolution of these granules that the transverse striæ make their appearance. By slow degrees the nuclei disappear, or their granules arrange themselves along with those of the fasciculus. Betwixt the primary fasciculi, delicate cellular fibres arise in small numbers; betwixt secondary fasciculi these fibres appear in greater numbers, which fibres by degrees present themselves as fibres of cellular substance.

With reference to the substance which is the bond of union between the primary fibres and which then connects the primary bundles, we can only say that such a substance must exist,—probably a soft hyaline substance of the greatest delicacy, but not demonstrable by itself.

The blood-vessels commence as a pectiniform capillary rete between the primary bundles, and then the vessels enlarge with the farther developement of the secondary fasciculi. The origin of the lymphatics, and their relations in the adult to the muscles, require additional research in order to be perfectly understood.

The nerves of the animal muscles are by so much the more zig-zagged or sinuous as the muscles are susceptible of being more shortened. They mostly present themselves as flattened cords, which are constantly forming plexuses. The mode of termination of these nerves, discovered nearly simultaneously by Valentin in Breslau, and Emmert in Bern, and all but seen by Prevost and Dumas at an earlier period, I have endeavoured to make evident by giving a drawing from a portion of one of the oblique muscles of the abdomen of the rabbit in *fig.* 91. This subject will be particularly spoken of when we come to treat of the nerves.

Whether at the point of junction between muscle and tendon there be an immediate transition of the primary muscular into the tendinous fibre, or there be a most intimate union of the two; and whether the genio and hyo-glossi muscles, &c. form a particular combination with the elastic tissue of the mucous membrane of the tongue or not,—are questions which have not yet been completely or satisfactorily settled (§ 250; *fig.* 51, *a*, 1; *fig.* 86, *a*, *a*) The muscles of the animal life rarely form any kind of tissue; such a structure, however, does result from the interlacing of the fasciculi of the lingual muscle (*fig.* 86).

Microscopic Examination of the Living Muscle of Animal Life.

§ 252. Prevost and Dumas* observed on the primary fasciculi (called by them *fibres musculaires secondaires*) of the sterno-pubic muscle of a living frog, which in a state of quiescence formed nearly straight cylinders, two changes, when by the stimulus of galvanism the muscle was aroused to action: 1st. The entire muscle became shorter, the primary fasciculus becoming very regularly zig-zagged. The alternating angles of the zig-zags were nearly everywhere equidistant, and measured from 50 to 110 degrees, the muscle shortening by 0·23. Less violent contractions of the muscle occasioned blunter angles in the zig-zags. The greatest contraction observed in a voluntary muscle, produced angles equal to 50° at the very utmost; the primary fasciculi of the muscles of the intestines fell into smaller angles but at greater distances. The angles of the zig-zag were repeated in the same direction in a direct line drawn transversely to the primary fasciculus, so that the parallelism of these was not interrupted; the single primary fibres of the nerves were seen running over the angles; the primary

* Magendie's "Journal." T. iii. p. 306.

nervous bundles were observed corrugated between the angles.*

§ 253. As nothing is superfluous in the animal body, and it might, therefore, have been inferred, *a priori*, that the length of the muscles must stand in a certain relation to their necessary contraction at the maximum of their action ; I have, nevertheless, thought it worth while to measure the fleshy bellies of some of the flexors and extensors of the extremities, in the passive and in the active state, the limb being first in a state of the most perfect extension, and then of the most complete flexion ; and I have found that this ratio is in fact determinate, but that it is modified in a greater or less degree by a variety of circumstances. It may suffice if I here state generally, that the contraction of the living muscle never approaches in amount that

* Professor Valentin repeated these experiments, but without making use of any adventitious stimulus. The muscles in the throat of a frog were selected for observation, which, exposed, were readily observed in action during the inspiration of the animal. In some observations which I instituted myself about the same time, I believed that I could always perceive certain vermicular motions, besides the contractions into zig-zags, of the corrugations of the primary fasciculi, not of the primary fibres. Professor Valentin and I together found the degree of contraction of which different muscles were susceptible, to differ considerably. Pieces twelve lines in length from different muscles were tried as to their capacity of contraction, and we found the piece from the masseter muscle to shrink to five lines, the piece from the pectoralis major to six lines, that from the longus colli to 6·5 lines, that from the latissimus dorsi to 7·5 lines, and that from one of the cutaneous muscles to eight lines. The animal which afforded the pieces of muscle was the horse just killed.

which we observe in a portion of muscular flesh removed from the body of an animal just killed.

§ 254. A delicate cellular substance invests and unites the primary into secondary fasciculi, and these become cognisable to the naked eye. Entire muscles, again, are surrounded by a strong sheath of cellular tissue; and in the extremities, moreover, by tendinous fasciæ connected with the general investing aponeuroses of the arm, leg, and thigh. Where the muscles in their actions have to shift their places extensively, they are separated by a layer of loose slippery cellular tissue.

§ 255. *Chemical Constituents of Muscle.*—One hundred parts of muscular flesh, from which, however, the vessels, nerves, cellular tissue, and blood could not be completely separated, contained—

Fibrine, vessels and nerves	15·80
Cellular substance	1·90
Albumen and hæmatosine	2·20
Alcoholic extract and lactic acid, lactate of soda, potash, lime, magnesia, and ammonia	1·80
Osmazome ? (Zomidin germ.) and three or four other watery extractive matters not yet certainly determined	1·05
Phosphate of lime with albumen	0·08
Water and loss	77·17
	100·00

§ 256. *Sensibility, Contractility, &c.* — The muscles possess little sensibility; their proper nerves, which are all derived from the anterior columns of the spinal cord, are accompanied by very few nerves of common sensation. But under the influence of the will and stimuli generally, the muscles exhibit the peculiar vital property called *contractility* in an eminent degree,—a property by which the parts in connexion with their opposite extremities are approximated, and the whole muscle becomes thicker, harder, and shorter. This contractility repeated experiments have shewn to be intimately connected with the nerves and blood distributed to the muscles: the nerves divided, the supply of blood cut off, muscular contractility is soon at an end.*

§ 257. The solid or voluntary muscles form a large proportion of the mass of the body. The destination of the muscles is obvious,—they are the means by which all the offices are performed essential to the preservation of the individual and the continuation of the kind. The least movable extremity of a muscle is usually spoken of as its *head* or *origin*, the most movable as its *end* or *insertion.* Muscles which are interrupted in their continuity by one or more tendinous portions are named *digastric* and *polygastric.* Some muscles are connected with tendons through their entire length, by which they are protected from overstretching, and the moveable parts upon which they act from too great degrees of displacement.

§ 258. The solid muscles are arranged according to their form into

1. Long muscles, and these are
    (*a*), Simple, fusiform muscles; and
    (*b*), Compound, cylindrical, or flattened muscles, of which there are many varieties: muscles having two, three,

* *Vide* Dr. M. Hall's "Memoirs on the Nervous System," and the elementary works on Physiology of the present time.

or many heads; having two, three, or more bellies; penniform and semipenniform muscles, &c. &c.;

2. Broad or membraniform muscles;
3. Short muscles; and
4. Annular or orbicular muscles, the habitual state and action of which are peculiar, inasmuch as they act independently of consciousness and of the will, like the organic muscles, their natural state being a state of tonicity; so that whilst the muscles at large become rigid after death, the orbicular muscles or sphincters become lax. The cause of this peculiarity, which must depend on some peculiarity inherent in their nerves, has not yet been explained.

§ 259. The solid muscles, like all the elements of the system of animal life, are symmetrical and in pairs.

§ 260. The muscles act upon the bones in the same manner precisely as cords do upon levers and rollers; by short contractions they elicit rapid and extensive movements, at the cost, however, as a matter of course, of considerable expenditure of power, for their points of attachment are commonly very close to the centres of motion.

Muscles sometimes move several parts, singly or together, according as the individual or collective points of attachment are fixed by other muscles or left free: the common muscle, the trapezius for example, can move the head, neck, and scapula, all together, or each of these parts by itself.

In situations where the tendons would, without assistance, reach the bony levers they have to move, at angles too acute, or where their original lines of traction require to be changed, we find processes of bone or of cartilage employed to increase the angle or to alter the line of traction; the contrivances made use of to this end are the sesamoid bones, of which the patella is the largest and most remarkable, and the trochleæ, of which we have beautiful instances in the pulley through which the tendon of the superior oblique of the eye passes, and the delicate hook of the sphenoidal bone over which plays the tendon of the tensor palati.

Muscles that are mutually opposed in their actions are entitled antagonists—such as the flexors and the extensors of the trunk and extremities, the one order being situated on the one aspect, the other on the opposite aspect, of the body or limbs. The mechanism of the motions in the animal body is, as has been said, entirely in accordance with the general laws of mechanics; the agent of the motions, however, muscular contractility, among all the known motory powers, exists in the living muscular fibre of man and animals alone.

TUBULAR OR HOLLOW FILAMENTOUS TISSUES.

§ 261. The primary fasciculi of the muscles and the nervous tubuli form the links of transition from the solid round filament to the hollow filament; we have seen that the peripheral layer of the primary muscular fibre is to be viewed as a tubular continuous membrane, having a certain consistency, being distinctly granular, and thereby streaked transversely, and that the inner portions of the same fibres, again, are to be regarded as an organised soft included matter. The primary tubuli of the nerves follow these in structure immediately; their contents, immediately after death at least, being of a tenacious consistency, and incapable of any rapid movement within the hollow including tubes. The capillary vessels are the first structures that are not only decidedly hollow, but in which the fluids they include move as something quite distinct from the vessels, and with greater or less degrees of velocity. All tubular structures, with the exception of the ducts of glands, are probably products or self-organised interstitial substances of the primary cells; in other words, intercellular networks of hollow elastic tissue.

NERVES.

§ 262. The nervous system consists of the brain and spinal cord, and of the nerves which in connexion with these are distributed to every part of the body. The brain and spinal cord are generally spoken of as the *central*, the nerves as the *peripheral*, parts of the nervous system.

In the brain and nervous system a *reddish grey*, inherently active, and a *white* distributing or conducting *substance* are distinguished.

The grey and active matter occurs in the brain as a superficial or cortical and general investing layer—a peripheral ganglionic substance; and in the interior of the brain and spinal cord as the central grey or ganglionic substance.

The white conducting, or intermediate tubular, or nervous substance, forms the white or medullary matter of the brain and spinal cord, and beyond the central portions constitutes the nervous bundles which are distributed to every part of the body that is susceptible of sensation and motion.

The different characters of these two substances depend on the dissimilar nature of their constituent elements. The grey matter consists for the most part of peculiar nervous cells, the *ganglionic globules* as they are called; the white matter consists of tubules, which, collected into bundles beyond the central parts, and inclosed in sheaths, form the nerves.

Diversities of Combination and of Properties connected with these.

§ 263. The nerves serve as conductors or parts intermediate between the central and the peripheral portions of the nervous system; they effect an intimate connexion betwixt the brain and the parts of the body that are susceptible of sensation and of voluntary motion. Nerves are either *direct*, that is, their root or central end is in connexion with the brain, and then they are called cerebral nerves, or they are *mediate*, in which case their roots are in connexion with the spinal cord, when they are called spinal nerves. With the brain and spinal cord they form the animal portion of the nervous system, and constitute the cerebro-spinal system, which, like all the systems of animal life, is symmetrical or alike in either half of the body divided in the mesial plane. The office of the cerebro-spinal system is to give information of the state of the peripheral parts of the body, and of the relations of external things to it and to one another, and also to preside over the motions dictated by the will and performed with consciousness.

The ganglionic system, different from the cerebro-spinal system, has no common central point in relation with formation and activity. It has, on the contrary, many smaller central organs which preside over especial processes, and cut off and render certain organs and systems more or less independent of the influence of animal life, and, consequently, of volition and consciousness. The *ganglia*, or nervous knots, which belong to this system, are constituted by the same inherently active matter of which the grey substance of the brain consists.

The cerebro-spinal nerves, with the exception of the soft or grey-coloured nerves of special sensation, such as those of smell, sight, and hearing, are white and almost entirely opaque, and are either purely sensitive, purely motory, or mixed sensitive and motory nerves, as they are destined for distribution to organs of pure sensation, of pure motion, or having the two-fold function of sensation and motion.

The cerebro-spinal system is itself subdivided into:

1st. The *cerebral system* of sense and of the soul. This consists of the brain and the nerves proceeding from it, which last are, 1st, nerves of special sensation — the nerves of the particular senses; 2d, nerves of common sensation; and 3d, nerves of motion, these being mostly connected with movements of the more delicate kind, and intended to aid or express the activity of one or other of the senses. The cerebral nerves form twelve pairs, which all proceed from the basilar aspect of the brain, and in general from the more central parts of the organ.

2d. The *spinal system*, consisting of the spinal cord and the nerves proceeding from it, these being either connected with the function of locomotion, with the peculiar sense of touch concentrated in the points of the fingers especially, or with the more general sense distributed over the entire surface, which we entitle common sensation. The spinal nerves, in their individual bundles, are either nerves of motion, of sensation, or of a mixed nature, fibres or fasciculi connected with each of these faculties, being bound up in the same sheath.

§ 264. The nerves of the sympathetic or ganglionic system are like the ganglia themselves, of a reddish grey colour, and transparent in a greater or less degree, and not symmetrical. The microscopic investigations of Retzius, J. Müller, and particularly Remak,* have recently shewn that the nerves of this system generally, contain an admixture of ordinary nerves or nervous fibrils, which proceed, according to Valentin,† from the brain and spinal cord, and probably preside over the functions of the vascular system—circulation, nutrition, secretion, &c. These adventitious nerves are so little nerves

* "Obs. Anat. et Microscop. de Syst. Nervos. Structura." 4to. Berl. 1838.

† Valentin: "De Functionibus Nervorum Cerebr. et Spinal." 4to. Bernæ, 1839.

of sensation, that they scarcely convey any but the most indistinct ideas of irritations impressed upon the vegetative organs. As the sympathetic nerves, besides the excitement of involuntary motions in the organic muscles, are intimately connected with the vascular functions, and always accompany the blood-vessels very closely, they are with great propriety named the organic or vascular nerves.

Microscopic Analysis of Nerves.

§ 265. The nerves consist, in general, of a congeries of delicate tubes, which, examined in an animal immediately after death, are found to be cylindrical and of like diameter, individually transparent, and in their interior to inclose a fluid which, however, speedily coagulates into a grumous, uniformly and very finely granular mass, although the separation of the coagulum into a thicker and thinner portion would seem to indicate a difference in the nature of its constituents. The nervous fluid probably separates imperfectly into a hyaline substance, which becomes grumous and finely granular in coagulating, and into a thick serum. The fine elementary tubes or primary fibres of the nerves, are connected by an amorphous matter, or by a more highly developed cellular substance into fasciculi and cords, and these involved in denser cellular sheaths constitute the nerves in the ordinary acceptation of that word.

More particularly examined, with the assistance of high powers and artificial light, a more delicate investing membrane is discovered within the outer thicker and sharply defined one of each particular fibre. This fine membrane appears to be composed of, or at all events to be covered by, a ciliary epithelium, the ciliæ of which lie very obliquely and apparently in spiral lines upon its inner aspect (*fig.* 88, 4, *a*, *b*, and 5).*

Soon after death the nervous tubes contract irregularly, probably in consequence of the unequal density of the contained fluid after its coagulation; the tube then, from cylindrical and even, becomes alternately contracted and dilated in its course (*fig.* 88, 3). Such a moniliform state of the nervous fibres at their origin in the brain and spinal marrow would even seem to be the natural condition; the knots or dilatations are certainly far more remarkable here than in the general course of the nerves. Immediately after death they present themselves in a cerebral nerve as they are represented in *fig.* 89, 7; and in a spinal nerve as they are depicted *fig.* 89, 8. Even after they have escaped from the spinal cord, the fibres are still somewhat varicose (*fig.* 89, 8, *a*, *e*); they only become regularly cylindrical when

* If this structure be confirmed by the observations of others, the nerves would come to be ranked among the true vessels. The peculiar structure in question was first noted by Professor Valentin in a course of observations upon the nerves of living animals, which we had undertaken in common about a year ago. The object of the movement of the nervous fluid in the interiors of the tubes, supposing it to be continued backwards from the ultimate loops, would be precisely that which is accomplished by the heart in regard to the blood—a constant, although perhaps, slow change of the contents of the nerves from the centre towards the periphery, and from the periphery towards the centre.

they are surrounded by the firm sheath of the nerve at large. These roots, moreover, are finer and more transparent than the fibrils of the rest of the nerve, and they are severally provided with a delicate covering.

In all probability two fibres of the roots of the nerves form a loop in the brain and spinal marrow as they do on the periphery. Here they are surrounded by the finest albuminous granules of the cineritious substance (*fig.* 89, 1), which, indeed, in some parts, seem to adhere to them like berries on a stalk (*fig.* 89, 7). The radicles of the nerves, which in the brain and cord are separate and distinct at first, unite as they pass beyond the central organs into fine fasciculi, which in the first instance are surrounded by the pia mater, and by and bye, where the smaller bundles unite into larger, by processes of the dura mater; as regards the spinal nerves, the fasciculi of the roots pierce the dura mater of the cord singly, and are then involved in common by a process from its outer layer. At the place where the process from the dura mater joins the nervous trunk which has now been formed, the fasciculi proceeding from the posterior columns of the spinal cord begin to cross and interlace, and form a ganglion, in which are included numerous isolated as well as clustered ganglionic globules, and from which also new fibres arise to swell the bulk of the future nerve of sensation, which is here finally completed in its structure (*fig.* 89, 2, 3, 4). The corresponding bundle, or nerve of motion constituted by the fasciculi which proceed from the anterior columns of the spinal cord, is intimately connected in its passage with the ganglion of the nerve of sensation, but without mixing obviously with it. The sensitive and motory bundles now form a common cord, each of these bearing reference in point of size to the destination and functions of the nerve which then generally proceeds by the shortest route to the parts it supplies, dividing into smaller and smaller fasciculi as it advances these secondary bundles, consisting, of course, of sensory or motory primary fibres, or of a mixture of the two according as the parts to which they are finally distributed are organs of sensation or of motion, or contain both motory and sensitive structures in their composition. The most careful examination discovers no difference in the structure and appearance of the bundles and their fibres whether they be connected with sensation or motion.

The continual divisions and subdivisions of the nerves imply a continually increasing expansion towards their peripheral extremities; each trunk, in fact, just as in the case of the blood-vessels, comes to represent a cone, the basis of which lies in the periphery, the apex towards the centre. The cones thus formed blend in various ways with one another, as the functions of the organs comprehended within them require, as it were, different nervous mixtures, such as we may presume could not have been conveniently formed at the commencement of the trunk. In the eye, for example, we see the peripheral expansions of many different nerves, in order to unite a variety of powers, and secure the requisite co-operation of the principal or more important nerves with others that are only accessory: in the organ mentioned we have the involuntary motions of the iris united with the voluntary motions of the eyeball; and then we have the special sense of sight associated with common sensation, with irritability, nutrition, and secretion.

§ 266. The nerves which proceed from different parts of the central system and unite in this way in their peripheral expansions generally combine in retes or networks, giving and receiving alternately bundles and isolated fibres from neighbouring branches; these bundles and fibres, however, merely joining with each other and proceeding side by side, never anastomosing and blending into single trunks as vessels do when they meet; the primary or ultimate fibres of nerves, in fact, only form loops or circles, they never end (*fig.* 104); the mutual interchange of bundles and single fibres is often extremely complicated, but no one is ever lost; it either returns upon itself, or joins some neighbouring fibre or fasciculus, and so begins its backward course to the central system whence it had proceeded. The reticular unions of the nerves are universally designated as *plexuses*, which are of different kinds:—1st, Plexuses of the roots; 2d, Plexuses of the trunks; 3d, Plexuses of the branches; 4th, Ganglionic plexuses; and 5th, Terminal or peripheral plexuses.

1. The *root-plexus* is a mingling of the roots of different nerves before or in connexion with the formation of nervous trunks; *e. g.* the plexus between the facial and acoustic nerve.

2. The *trunk-plexus* is a mingling of the trunks of different nerves; *e. g.* the axillary plexus.

3. The *branch-plexus* is a blending of the branches of nerves; *e. g.* the facial with the trigerminal.

4. The *ganglionic plexus* is mostly observed among the organic nerves, and is divided into (*a*) *internal* or *cellular plexuses*, in which the nervous bundles meeting in the ganglions open and make interchanges mutually of the primary fibres which inclose ganglionic cells (*fig.* 107); (*b*) *external ganglionic* or *radiated plexuses*, which are radiated combinations of organic nervous trunks and branches by means of ganglia; *e. g.* the solar plexus, the mesenteric plexus, the renal plexus, &c.

5. The *terminal plexuses* are formed by the finest and most delicate ultimate bundles, and occur of various degrees of complexity in the entire periphery of the nervous system. Those of the organic nerves are as yet but little known; those of the voluntary muscles, however, have been fully examined (*fig.* 91). The terminal plexuses of the nerves of touch and of common sensation are remarkably developed (*figs.* 93 and 94, upon a section, and 95 upon the surface of the corium).

Peripheral Terminations or Expansions of the Nerves.

§ 267. From the ultimate peripheral plexuses of the nerves individual primary fibres at length take their departure and form terminal loops; or, otherwise, the finest fasciculi and cords resolve themselves into primary fibrès which form the terminal loopings, these being always constituted by two primary fibres from the same or from different fasciculi. Such final loopings present themselves wherever peripheral nervous influence or impressibility is manifested; for the nervous workings in the various organs depend not upon the trunks, branches, ramuscles, or even the most delicate fasciculi; but upon these final loopings of the nerves, which are, therefore, the necessary media by which the motory nerves elicit motion, the sensory nerves convey sensation. The pain or impression produced in the point of the trunk of a nerve which is irritated, and which usually accords in kind with that which belongs to the peripheral expansion, depends, as my discovery has shewn, upon the presence of terminal loopings in the fasciculi themselves (*fig.* 162, *b c d*, *e f g*, *h i m*),—nervi nervorum, in short, which stand in the same relation to the nerves as the vasa vasorum do to the larger blood-vessels.

§ 268. The final loops of the organic muscular nerves are still but little known. Those of the animal muscular nerves have been more studied; they are generally of considerable size: from a terminal fasciculus, which generally runs parallel with the muscular fasciculi, primary fibres proceed, and forming wide arches across the line of the muscular fasciculi, associate with another nearer or more distant nervous bundle and begin their backward course (*fig.* 91). According to Prevost and Dumas the muscular bundles can be seen bending during their contractions in considerable angles along the line of these nervous arches (§ 252).

§ 269. The final loops of the nerves of sensation, those of touch in especial, are less open than the final loops of the voluntary muscles (*figs.* 97 and 98). In those that surround and that penetrate the bulbs of the hairs, the loops seem even to be completely, or all but completely, closed (*fig.* 94, *h*, *h*, *c*, *c'*); those of the pulps of the teeth are also, according to Valentin, but very slightly open (*fig.* 105); and, like the loops in other situations, are formed now from primary fibres proceeding from and returning to the same bundle (*fig.* 98); now proceeding from one and returning to different and more distant bundles (*figs.* 92 and 97). The final loopings in the less sensitive portions of the skin comport themselves like the associated capillary inosculations of the blood-vessels, which have long been familiarly known (compare *figs.* 97 and 98, with *fig.* 137; and *fig.* 92, *e*, with *fig.* 138); and where the final loops resolve themselves into many subordinate or smaller ones by doublings and convolutions for the purpose of forming a multiplier for the peripheral neuro-electric function, as they do in the tactile papillæ (*fig.* 92, *e*, *f*; *fig.* 93, *d*, *d*, *d*), the peripheral distribution of the capillaries will be found to be of the same description (*figs.* 138 and 139). The highly sensitive tactile papillæ seem often to consist of a single greatly convoluted primary nervous fibre (*fig.* 99). Fusiform multipliers of the same kind are occasionally formed in the course of straight primary fibres (*fig.* 100). Several shortly convoluted terminal loops disposed like the segment of a sphere sometimes form the rosette-like nervous or tactile papillæ which are exhibited in *fig.* 101. Between such tactile rosettes, or capitulate nervous papillæ, we sometimes observe simple loops included; for example, in the finger of man (*fig.* 93, *c*, *c*).

Organic or Ganglionic Nerves.

§ 270. The ganglionic nerves are called organic because of their obvious connexion with the organic or vegetative functions; they are also sometimes spoken of as nerves of the vascular system, from their close alliance, not merely with the offices, but with the trunks and branches of the blood-vessels, very different from the cerebro-spinal nerves which only associate themselves with the ultimate inosculations of the vascular system.

It is possible that the persistent cellular fibres, which surround the oftentimes scantily distributed primary nervous fibres in relatively larger proportion (*fig.* 163) may serve as subordinate means of conducting the nervous influence; at all events, that these peculiar cellular fibres may stand in closer relationship to the nervous system than the embryonic or transition form of cellular fibre which has the faculty of assuming other shapes, such as cellular membrane, tendon, &c. We, indeed, find that not only are the soft or organic nerves and the branches of vessels surrounded by these persistent cellular fibres (*fig.* 163), but that the primary nervous fibres are very constantly accompanied by them (*fig.* 102, *c*, *c*; and *fig.* 103, *d*, *d*). The finest fasciculi of the animal nerves seem to be surrounded and accompanied in the same way; the cellular fibres, according to Remak's observations, first quit the nervous bundles when they proceed to form terminal plexuses, and may still be seen in the shape of retes within the meshes of these (*fig.* 106). The ganglionic globules are further surrounded by the same form of cellular fibre in the ganglia themselves (§ 271), as they are when they occur in the course of the ganglionic nerves. The nuclei of the peculiar cellular fibres in question are granular (*fig.* 102, *d*).

The finer fasciculi of the nerves of sensation frequently open up in the manner exhibited in *fig.* 90. The peripheral terminations of the nerves are peculiar in some of the special organs of sense; for example, in the eyeball. Here the end of the optic nerve expands in the guise of a hollow hemisphere, and forms the retina which consists of two layers, viz. a granulated fibrous reticular layer, and a layer of dispersed granules. The olfactory nerve forms in the substance of the mucous membrane of the nostrils a flat, extremely delicate, and fine-meshed terminal plexus without any apparent final loopings of primary fibres.

Ganglionic Globules or Cells; Grey Nervous Substance; Ganglia.

§ 271. In the grey matter of the brain and spinal marrow, intermixed with blood-vessels, albuminous granules, grey organic or naked fibres, and nascent roots of nerves, which form the largest portion of the mass, we observe numbers of rounded, relatively large, granular cells, inclosing granular eccentric nuclei and nucleoli; these are the *ganglionic cells* or *ganglionic globules* (*fig.* 89, 2, 3, 4). They are either rounded, more frequently ovoidal and ellipsoidal, or more rarely pyriform or fusiform in shape. They vary considerably in point of size, being to the blood-discs in the ratio of two, three, four, or five to one. They bear a strong resemblance, as Valentin has remarked, to the unimpregnated ova of the ovaries: the granular contents remind us of the yolk, the nucleus of the germinal vesicle, and the nucleolus of the germinal spot (the two last, like the cell, consist entirely of granules). They are immediately surrounded and connected by a tissue of organic fibres (§ 264, *fig.* 89, 5, *a*, *a*); and more than this, in ganglia they are included between the outgoing and incoming interlaced fibres of the white and grey nerves (*fig.* 107).

The ganglionic globules are contained, 1st. In the grey central and cortical substance of the brain and spinal cord. 2d. In the trunks of nerves, viz. at the place of contact or of union between the root of the nerve of sensation and the corresponding root of the nerve of motion, as in the fifth cerebral and all the spinal nerves; in the course of the grey organic nervous trunks—the sympathetics—either isolated and mixed with their substance, or collected into clusters without sensibly increasing their diameter. 3d. In the peculiar ganglia of the trunk and branches of the sympathetic nerve.

§ 272. Peripheral impressions are transmitted to the nearest ganglion with which the part of the periphery impressed is connected, and are received with or without consciousness, according as the receiving grey or ganglionic substance is contained in the brain or spinal marrow, or in one or other of the disseminated ganglia. From thence follows, in a centrifugal direction, the nervous reaction which is proclaimed or manifested by motion — reflex motion, or by phenomena or actions of other kinds, either in the impressed periphery itself or in its neighbourhood, or in some more distant part only connected with that peculiarly impressed in virtue of the general association which makes one whole of the nervous system.

Origin and Developement of the Nerves in the Embryo.

§ 273. In the embryo the nerves are found to arise essentially in the same manner as round filaments and the primary bundles of muscles. The embryonic cell-substance arranges itself into cell-fibres, and from the very finely granular intercellular filaments, which are not yet white, but of a reddish grey and transparent, like Remak's organic fibres, arise the primary fibres of the nerves. As was rightly observed by Schwann, the white colour of the nerves first appears when within the delicate boundary line a sharper contour is perceived, indicating the outer surface of the proper nervous tubulus or hollow filament, to the inside of which a fainter line is by and bye seen, announcing the inner aspect of the tubulus, as distinguished from its contents. Meantime the nuclei, which had at length been separated by considerable spaces, disappear. The delicate outer covering of the now completed nervous filament, however, still remains in the shape of a continuous pulpy substance, and is therefore to be regarded as the intercellular connecting hyaline matter or cytoblastema, in which, as between the fasciculi of the muscles, the cytoblasts make their appearance, which then go on to be evolved into the cell-fibres and connecting cellular filaments of the nervous fasciculi, and which belong not to the nervous filaments but to the somewhat later formed derivatives from the cellular substance.

Such is the view that has been taken by all observers of the mode of origin and formation of the nervous system betwixt its central and peripheral portions. But we have still to ask, in what manner the central and the peripheral portions of this great system originate and attain to their complete developement? Here as elsewhere, doubtless, and particularly as regards the periphery, the terminal plexuses and loop-like bendings of the primary fibres must stand in a certain determinate relationship to the surrounding structures.

§ 274. As in every other particular organ and system of the body, we observe diversity between the texture and general characters of the central, of the middle or transition, and of the peripheral or extreme portions of the nervous system. The peripheral parts of the vascular and nervous systems present too many points of analogy or rather identity in their forms, to permit of any doubt being entertained as to the similarity of their mode of developement. The terminal plexuses of the nerves exhibit the same type in the particulars of relative size and arrangement of parts, as the arterial and venous networks; the terminal loopings of the nerves have, in fact, capillary terminal nooses of the vascular periphery as regular attendants. We have already alluded to the suspicion or idea that the elastic tissue was an organised residuum of the primary or embryonic intercellular substance (§ 210). As regards the capillary vascular retes, this view, especially when the vessels of bone are considered, appears highly probable;* but in the absence of positive observations we can only speak of it as a probability, that the periphery of the nerves at large, like the capillary retes, arises or is developed from the primary or embryonic intercellular substance.

Chemical Composition of Nervous Matter.

§ 275. According to the analysis of Berzelius 1000 parts of cerebral substance contain—

Water	800·0
Albumen	70·0
Cerebral fat { stearine 45·3, elaine.. 7·0 }	52·3
Phosphorus	15·0
Extractive matter (osmazome?)	11·2
Phosphoric salts and sulphur	51·5
	1000·0

The chemical analysis of nervous matter, like that of any other system which is made up of a variety of constituents, will have a much higher value in reference to general anatomy when each of these constituents is regarded separately; when as concerns the brain, for instance, the cortical and the central grey substance, the white or medullary

* See in the section on the Vessels what is said of the origin and evolution of the blood-vessels of bone.

substance, the soft organic nerve, and the harder animal nerve, are distinguished and severally subjected to analysis.

In the cerebral substance oil-globules are very rarely seen, fat cells perhaps never; the fatty element of the brain would seem, therefore, to be mostly in a state of combination. Even the nerves present no other fat to the eye than that contained in the cells which so constantly accompany not only the trunks and larger branches, but the finest fasciculi and even the primary fibres themselves. The brain in all probability contains a variety of salts, particularly phosphatic salts; whether it contains any free acid or not has not been determined.*

VESSELS.

§ 276. The vessels form a very considerable portion of the mass of the animal body. They are membranous branched tubes in which different fluids circulate; these fluids being either fully elaborated blood, or lymph and chyle which flow into the blood, for its maintenance in adequate quantity. Sometimes the ducts of secreting glands are reckoned

* Macerated in water at the temperature of the air, the brain rapidly becomes soft, forming a kind of emulsion, in which state it has a peculiar and disagreeable odour, but that is neither fetid nor ammoniacal. Subjected to the action of boiling water, the cerebrum and medulla oblongata undergo scarcely any change of form; but when the operation of boiling is continued uninterruptedly for ten hours, both the medullary and cineritious part of the cerebrum appear rather contracted, and they become harder and more friable, and feel greasy. — See Dr. Davy's *Researches, Phys. and Anat.* vol. ii. pp. 380, 313, and 320. — *G. G.*

among the number of the elements of the vascular system; vessels have, therefore, been classed according to their contents into 1st, lymph-vessels (lymphatics and lacteals); 2d, blood-vessels; and 3d, secreting vessels. The lymph-vessels, with their associated glands, form the system of lymphatic vessels; the arteries, and veins, and central organ of the circulation, form the system of blood-vessels; the secretion-vessels form the system of secreting vessels or the proper glandular system.

Vessels serve 1st, for the absorption of fluids from without, or the reabsorption of those which already received into the body had escaped into the interstices of the tissues—the chyle and lymph-vessels; 2d, for the distribution of the blood to every part of the body, as a means of enabling it to accomplish its destined offices, and to maintain itself with its appropriate qualities—blood-vessels; 3d, for the separation and removal of various matters from the blood, either to preserve this fluid in its integrity, or to effect certain purposes in the periphery of the body—secreting and excreting vessels.

The blood-vessels, which belong to the system that is universally distributed, form networks in the periphery; the lymphatics in their course form convolutions called lymph-glands; the secreting and excreting vessels, generally speaking, present nothing of the kind. The blood and lymphatic vessels are lined in the interior with the same serous membrane, a simple, and in the embryo tessellated epithelium. The secreting and excreting vessels are either inversions of the corium or mucous membrane, or of their epidermis or epithelium.

Lymphatic or Absorbent Vessels.

§ 277. The structure and function of the lymphatics are the same in every part of the body; their contents, however, vary, and they are therefore divided into chyle or lacteal, and lymph vessels.

§ 278. *Lacteal vessels.* The commencement of a lacteal vessel, according to Krause,* is an extremely delicate vesicle, or cellule, formed of the finest cellular substance, and produced into a narrow transparent canal, which consists of the inner vascular membrane alone; this speedily anastomoses with the nearest delicate lacteal vessel; and, in this way, a very dense or fine-meshed rete is formed. From the networks larger lacteals proceed, which, however, are, for the most part, no more than from the 20th to the 5th of a Paris line in diameter (*fig.* 113). I have myself observed the lacteal vessels in many parts of the small intestines of a dog, on the villi of which the chyle here and there presented the appearance of a white earthy precipitate; and, under similar circumstances, in several others of the domestic animals and in man. Most probably, however, the roots of the absorbents were only imperfectly filled, and their commencements not at all distended in these observations. Perfectly fresh villi, from the human intestinal canal of man and the domestic mammalia, presented, under favourable circumstances, the following appearances:—The nuclei of the pyriform cylinder-

* Handb. d. Mensch. Anat. Bd. I. S. 28.

epithelium which covers the villi, present themselves in the guise of hollow pediculated vesicles (*fig.* 240, *d*; *fig.* 241, *b*); the cavities of these appear to communicate with larger lymph-vessels (*a*), which not unfrequently hang together and inosculate in the manner of the meshes of a thick net. From such networks the finest lacteals proceed; and these, still continuing to inosculate freely, form a more open net with elongated meshes (*fig.* 241), very much in the manner of the blood-vessels as they are seen in the longitudinal section of a cylindrical bone (*fig.* 61). It seems probable, that secreting vessels of every kind take their origin in nucleated vesicles, of the same description as those of the lacteals; the presence of the chyle in these vessels might, therefore, with apparent propriety, be viewed as the effect of a process of secretion. The chyle has been already described in § 42, 50.

§ 279. *Afferent, or Peripheral Lacteal Vessels.*—These are disposed between the two serous laminæ of the mesentery, sometimes by the sides of the blood-vessels and nerves, but sometimes apart from these, and run straight from the intestine to the mesenteric glands. The lacteals can be demonstrated to consist of three coats; 1st, the universally present serous or inner tunic; 2d, a layer of spirally-disposed, fine, reddish-coloured fibres, of the nature of the contractile or of the muscular tissue; 3d, an outer coat of cellular substance, the component fibres of which run spirally around the vessel, as well as in the line of its length, the tissue being mingled with the fibres which Remak characterised as organic fibres.

The peripheral lacteal vessels anastomose, or unite, but rarely, and always at very acute angles; their diameter varies greatly, neighbouring vessels measuring one-tenth, one-half, and three-quarters of a line in diameter. They have numerous valves, which give them a knotted appearance externally (*fig.* 108, *a*, *e*, *f*). They are formed in the same way as the valves of the veins, generally of two semi-lunar folds of the inner coat of the vessel, placed opposite one another, and having contractile fibres in their interior (*figs.* 114, *i*, and 115, *e*). The valves of the lacteals have the same functions as those of the veins, viz. to prevent the reflux towards the intestines of the fluids contained in the vessels, whilst the accumulation of this fluid behind, and motion and pressure of every kind, tend to force it on towards the mesenteric glands and the heart.

§ 280. If we regard as CHYLE all the matters newly taken up from the intestines, and capable, by assimilation, of being turned into blood, and as LYMPH, all the fluids that are re-absorbed after having escaped from the current of the sanguiferous circulation, it is still obvious that the terms chyle and lymph, chyle-vessels and lymph-vessels, or lacteals and absorbents, are merely relative terms; for the chyle-vessels do not transport newly-elaborated matters only, but the lymph of the stomach and intestinal canal also; and the lymphatics, those of the lungs and skin in particular, sometimes carry new matters, as well as such as have already and for some time existed as constituents of the body.

The glands which we observe in such numbers at the root of the mesentery, and which are, therefore, called mesenteric glands, are, like the conglobate or lymphatic glands in general, convoluted or plexiform masses of lacteals, assuming the appearance of solid fleshy organs. The mesenteric glands are interposed between the peripheral and central orders of abdominal absorbent vessels. By means of the glands in question, the chyle, probably with a view to its assimilation, is brought under the peculiar influence of the organic nerves, at the same time that it is in intimate contact with a large amount of living, organic surface. The branches and subordinate divisions of the lacteals anastomose freely in these glands, and the finer twigs finally form a pretty uniform, close, and fine-meshed rete, which again, gathering itself into minuter and then into larger branches, these unite and produce efferent vessels, which carry the fluid onwards in its course. The mesenteric glands are well supplied both with blood-vessels and nerves, which pierce them at every point, and surround the various subdivisions of the lymphatics. The various constituents of the mesenteric glands, as now enumerated, are connected by means of cellular substance.

The mesenteric glands, therefore, unite a portion of the periphery of the vascular and of the nervous system with their own proper substance, — with the reticular mass of lacteal vessels of which they principally consist; and as the efferent vessels proceed, after the formation of the glands, in the same onward direction as the afferent vessels, they may be held as standing in the same relation to the blood-glands generally, as the fusiform nervous papilla (*fig.* 100) stands to the more ordinary form (*fig.* 99); and as the primary bundles of the nervous ganglia open up, and resolve themselves into their primary fibres, which, after surrounding the ganglionic cells, again unite, and form an onward trunk (*fig.* 107), so the lymphatic glands, which have an analogous structure, are often, and not inappropriately, spoken of as *lymphatic ganglia ;* and, by an extension of the same views, the spleen, thymus, thyroid, and supra-renal bodies, are sometimes mentioned under the name of *blood-ganglia.*

Three forms of chyle-glands are distinguished :—

1st. *False glands.* These are small and loose, and form flattened, circumscribed net-works of lacteals (*fig.* 108, *d*). Several of the finer peripheral absorbents unite and compose a narrow-meshed rete, from which several smaller or a few larger inter-glandular vessels proceed, which generally then form a proper gland; or they proceed at once, passing the proper glands, to empty their contents into larger vessels (*fig.* 108, *c*), or they become trunks themselves, and advance towards the heart. Such false glands as have now been mentioned are generally found buried among loose cellular substance, in the vicinity of the periphery of the system to which they belong.

2d. *Scattered peripheral true glands.* These are small, flat, lenticular, scattered, of a reddish grey colour, and from a quarter of a line to a line and a half thick, by from one to four lines in diameter. They are situated nearer to the periphery of the absorbent system than the central glands, generally betwixt these and the reticular or false glands, near the intestine, and between the folds of the mesentery.

3d. *Accumulated, or central true glands.* These are the largest chyle-glands met with; they are generally lenticular and flattened, seldom perfectly circular, generally ellipsoidal or cordiform; they lie at the root of the mesentery, near the receptaculum chyli or thoracic duct, and crowded together. They receive the whole of the chyliferous vessels which had gone to the false and to the isolated glands. The vessels which proceed from these glands are the central lacteal, or absorbent vessels, and either terminate in the thoracic duct or immediately in a vein; they rarely form interglandular vessels, or vessels which as efferents, again form glands.

On the anterior mesenteric artery of the dog, there is a singular long-shaped chyle-gland—the pancreas Asellii.

Interglandular Lacteals.

§ 281. The afferent vessels often form ganglions or glands once and again, from which the proper central vessels then take their origin; this is much more commonly the case with the lymphatics than with the lacteals. I entitle them *interglandular vessels*, from their connexion at either extremity with a gland, to the one of which they, of course, stand in the relation of peripheral, to the other of central vessel. They are generally larger than the peripheral lacteals, and contain fewer valves than these.

§ 282. From the central glands, lymph or chyle-vessels proceed, which terminate in neighbouring veins; these lymph-ducts comport themselves in their course in the same manner as the central and interglandular vessels. At the points of their termination in the veins, various forms of valvular apparatus are observed, which effectually hinder the reflux of the chyle just poured into the vein, or the entrance of the blood into the absorbent. I have observed three forms of these valves :—

1st. *Simple opercular valves*, of the same nature as those that commonly guard the mouths of entrant veins (compare *fig.* 112, *c*, with *fig.* 114, *e*). These are generally observed where the lymph-ducts enter the veins at acute angles.

2d. *Semilunar valves, in pairs*, of the nature of those generally observed in the trunks of veins, and which consist of two opposed semilunar folds of the inner coat of the vessel. This form of valve is usually found where a lymph-duct joins a vein perpendicularly or at right angles to its axis (vide *figs.* 110 and 111 ; *c, d*, the valve closed ; *f, g, h*, the valve open).

3d. *Compound valves*, made up of a combination of forms 1 and 2 (*fig.* 112). At the end of the valve *e*, the inner membrane forms two semilunar valves *d, d.**

Central Chyliferous Vessels.

§ 283. Those vessels which bring the chyle from the glands directly into the thoracic duct are generally spoken of as the central or proper efferent vessels. They generally quit the glands few in number, and are of larger size and shorter than afferent

* In the horse it is not uncommon to meet with these lymph-ducts, or absorbents, terminating directly in the veins. In other domestic animals, and in man, I have never seen any arrangement of the same kind that was not questionable. In all probability, however, they exist generally.

vessels; they are also, like the interglandular vessels, beset with fewer valves than the peripheral lacteals and absorbents. They collect, for the major part, in the root of the mesentery, around the superior mesenteric artery, and over the abdominal aorta, where they form several trunks, about half or three-quarters of a line in diameter in man and the smaller domestic mammalia, from a line to a line and a half in the horse, ox, &c.; and these, with such accessions as they receive from the central lymphatics, pass over, for the most part, and end in the receptacle or reservoir of the chyle, situated to the right of the abdominal aorta.

§ 284. The receptaculum chyli is the dilated, and often branched varicose commencement of the trunk or principal vessel of the absorbent system, in which the major part of the chyle, and of the lymph of the abdominal extremities, is collected and mingled.

§ 285. The thoracic duct, generally simple, but still accompanied by certain central vessels, conveys the mingled lymph and chyle on the right of the aorta, by the side of which it enters the thorax; but, by and by, dipping under the great artery of the body, it crosses between that and the body of one of the dorsal vertebræ to the left, and pours its contents into the left axillary vein in man and the mammalia. Mingled with the blood, the lymph immediately enters the right side of the heart, and, being sent from thence, it undergoes exposure in the lungs, and, in all probability, receives its ultimate developement as blood in the course of the lesser circulation.

The matters taken up along with the chyle from the intestines, which are unavailable in the economy, and the effete substances, which proceed from the workings of the machine itself, are abstracted by various systems of depurative organs: — superfluous water by the lungs, the kidneys, and the skin; salts by the kidneys and skin; carbon by the lungs and liver; azotized matters by the kidney; hydrogen by the liver; volatile and odorous matters by the lungs, the skin, &c., in the shape of watery vapour, carbonic acid, bile, urine, fæces, &c.

Lymphatic Vessels, and Lymphatic Glands.

§ 286. These, in appearance, structure, &c., are identical with the lacteals and mesenteric glands. The lymphatics arise as retes in all the soft parts of the body (*fig.* 108), particularly under all the external and internal surfaces, surrounded by much finer vascular capillary reticulations. They, by and by, combine into particular vessels, and these take their course in the subcutaneous or submembranous, and interstitial or interorganic cellular substance, generally at no great distance from the subcutaneous veins; they then approach the principal vascular and nervous trunks, forming false lymphatic glands, or fine-meshed, circumscribed networks in their course (*fig.* 108, *d*), and also peripheral (*A*, *A*) and central glands or ganglions, in the spaces filled up with loose cellular substance.

The central lymphatic glands appear to form finer transition networks than the lacteal glands. The lymphatic glands generally present themselves in clusters, and much more regularly in certain situations than in others, viz. where the great vascular and nervous trunks divide to supply internal organs or the extremities, and where these subdivide to furnish particular sections of the limbs :—about the root of the lungs, the bottom of the neck and angle of the jaw, the axilla and bend of the arm, the groin and ham, &c. They are always embedded among loose cellular substance, are of a reddish yellow or reddish grey colour, of different sizes, flattened and of a lenticular shape, or more elongated. The lymphatic glands that surround the first division of the bronchi are of a slate grey, or black colour, which is generally deeper the older the subject is. The most remarkable clusters of glands are—

1st. That about the angle of the jaw and top of the larynx, the *laryngeal cluster*.

2d. The *œsophogeal cluster*, which lies deeper and lower down than the preceding.

3d. The *cervical cluster*, at the bottom of the neck.

4th. The *axillary cluster*, lying upon the axillary artery, vein, and nervous plexus.

5th. The *inguinal cluster*, lying upon the femoral artery, vein, and crural nerves.

In the thorax :—

6th. The *cardiac cluster*, lying upon the great issuing and entering vascular trunks and cardiac plexus of nerves.

7th. The *bronchial cluster*, lying upon the first division of the bronchi, and the arteries, veins, and nerves of the lungs.

In the abdomen :—

8th. The *hepatic cluster*, lying over the hepatic vessels and nervous plexus.

9th. The *splenic cluster*, between the laminæ of the gastro-splenic ligament, and over the splenic vessels and nerves.

10th. The *lumbar and pelvic clusters*, over the division of the abdominal aorta, and over the pelvic arteries, veins, and abundant nervous plexuses.

Lymphatic interglandular Vessels.

§ 287. Between the upper and lower part of the neck, and between the first and second articulations of the extremities, we observe large lymphatic vessels, which I propose to designate by the above title, inasmuch as they are afferent vessels to peripheral and efferent vessels to central glands, and connect these with each other; by such vessels are the glands at the bend of the arm connected with those in the axilla, those of the popliteal cavity with those of the groin, those of the superior part with those of the lower part of the neck. The vessels in the latter situation are very large in the horse, often of the diameter of a good-sized goose-quill, and lie by the side of the trachea and behind the carotid artery (*fig.* 109).

Efferent Lymphatic Vessels and Lymph Ducts.

§ 288. The efferent or central lymphatic vessels (*fig.* 108, *b*,) connect the central glands with the thoracic duct; the lymph-ducts pour the central lymph immediately into the veins. The valves which guard the anastomoses thus formed are of the same description as those that protect the inosculations of the chyliferous ducts with the veins (*figs.* 110, 111, 112).

§ 289. As the very finest lymphatics are still considerably larger than the system of intermediate peripheral blood-vessels in the passage of arteries into veins, wounds, abscesses, &c. may give occasion to the entrance into the general circulation of pus and other corpuscles of larger sizes than the blood-discs. These flow readily enough on to the heart; but forced into the lungs, they are apt to stick fast in the capillaries of these delicate organs, impeding the circulation through them, and after the lapse of a few hours giving rise to exudations and to the formation of cytoblast tubercles (§ 108 and 109).*

§ 290. Indubitably, also, stases of the lymph and chyle occur in the glands connected with the lacteal and lymphatic vessels, either in consequence of the coagulation of their contents, or of inflammation of the vessels themselves. The effects of such stoppages are not only frequently obvious among the larger glands in depositions of albuminous matter, the solvent of which, the serum, has been removed by absorption, but also in the innumerable peripheral false glands. In the scrofulous diathesis, it is well known to what an extent the central as well as the peripheral lymphatic glands will enlarge; and when examined microscopically, their pathological

* In examining the bodies of an unborn fœtal horse, and of one that had just been born, I found the glands about the upper part of the throat in a state of suppuration, the interglandular vessels filled with pus, and in the lungs the usual consequence of this, viz. rounded cytoblast tubercles with pulpy contents. In two other instances I had no difficulty in discovering numerous pus-corpuscles mingled with the blood. In these instances there was suppuration of an extreme part, and cytoblast tubercular formations in the lungs.

contents, besides imperfect exudation-corpuscles, present albuminous granules and amorphous coagula in quantities by so much the larger, as the glands examined belong more completely to the periphery, and as the formation of fibrine seems to have been rendered difficult by the discrasy of the fluids or general cachectic condition of the individual.

§ 291. With regard to the origin and developement of the lymphatics little is known. In the immediately succeeding section upon the blood-vessels, the views most reconcilable with our knowledge of other analogous points will be found detailed.

THE SANGUIFEROUS SYSTEM.

§ 292. The sanguiferous vascular system comprises the heart and the entire series of branched membranous tubes which, taking their rise from the heart, are distributed to all parts of the body, and from these return again to the central organ whence they set out, receiving the lymphatic vessels when near the end of their backward course. The blood-vessels are of two kinds, which differ from each other both with reference to structure, and to the part of the circulation in which they are severally engaged. Vessels of one kind are remarkable for the strength, thickness, and high elasticity of their walls, and transmit the blood from the heart to every part of the body,—these are the *arteries;* vessels of another kind are distinguished by the thinness but toughness of their parietes, and return the blood from the extreme parts of the body to the heart,—these are the *veins.* The circulating system itself naturally falls into two great divisions: the one having reference to the system at large—the systemic, aortal or greater circulation; the other to the lungs—the pulmonic or lesser circulation. The first consists of the left auricle and ventricle of the heart, of the aorta and its branches, and of the veins which the aortal system supplies; the second comprises the right auricle and ventricle of the heart, the pulmonary artery and its branches, and the pulmonary veins. Sometimes the peculiar circulation of the liver is spoken of apart, and under the title of the portal circulation, as a third form of circulation; and it certainly is unlike aught that we observe in any other part of the body; the whole venous blood of the chylopoetic system, instead of being poured into the great returning trunk of the system in its vicinity, to reach the heart immediately, being first collected into a single vessel, and this undergoing division in the substance of the liver, like an artery, before the round is completed.*

§ 293. The end of the greater circulation is to supply all parts of the body with decarbonized blood, which is essential to their nutrition and to the manifestation of their appropriate vital endowments. The object of the lesser circulation is obvious: it is to expose the blood which has returned to the right side of the heart of a deep black colour, loaded with carbonic acid and impurities we may presume, and become unfit in this condition for the uses of the economy, to the action of the atmospheric air which is taken into the lungs; by

* The valuable observations of Mr. Kiernan should be consulted concerning the blood-vessels of the liver.—See *Philos. Trans.* 1833, part 2.—*G. G.*

which it is freed from much carbon and watery vapour, and during which it acquires a bright vermilion colour, and is again fitted to minister to the wants of the economy. The circulation through the portal vein effects the purification of the blood mixed with chyle from carbon and hydrogen, and perhaps from certain foreign matters which have been taken up from the intestines; it also serves for the secretion of the bile. There is, therefore, an obvious similarity between the objects of the circulation through the lungs and of that through the liver; carbon and hydrogen, or water, are the grand elements separated by each, these substances passing off from the lungs in the gaseous and vaporous form, from the liver in the shape of a peculiar fluid, which immediately becomes, to the best of our knowledge, an important agent in chymification and chylification.* The trunks and branches of the arteries and veins generally lie side by side

* Dr. Willis has lately given an ingenious and interesting account of the "Signification and Ends of the Portal Circulation," (*Lond. and Edinb. Monthly Journal of Medical Science, September* 1841), in which he brings many facts and arguments to prove it *a means of economising arterial blood.* Had the liver been supplied direct from the aorta, it must have had a vessel of a calibre equal to the sum of the whole of the vessels whose refluent blood is collected into the trunk of the vena portæ. This would have implied the necessity for larger respiratory and central circulating systems than under existing arrangements are found sufficient; for the bright blood of the abdominal viscera, after having vitalised the organs to which it is distributed, though effete in one sense, will still afford the elements of bile if subjected to the peculiar elective affinity of the liver. There is nothing, he thinks, in the blood of the portal system which fits it more than any other blood to afford bile. In the two lowest

in their course, and are very constantly accompanied by nerves of greater or less magnitude according to circumstances.

The Heart.

§ 294. The heart is a powerful muscle having four cavities or chambers in its interior, the entrances to, and exits from which, like those of a double-action pump, are guarded with valves so disposed that by the simple alternate contraction of the auricles and ventricles, the blood which is pouring in upon it from the venæ cavæ and pulmonary veins is necessarily forced into the great arterial trunks which here take their rise (§ 53 and § 246).

The Arteries.

§ 295. The arteries receive the blood immediately from the ventricles of the heart, and distribute it to all parts of the body. They are divided into the arteries of the greater circulation, or aortal system, and those of the lesser, or pulmonic circulation. The walls of the aortal system of arteries are thicker and stronger than those of the pulmonic system, in the same proportion as the walls of the left ventricle are thicker and stronger than those of the right, and as the resistance to be overcome in sending blood to the extreme parts of the body is greater than that which is met with in supplying

classes of vertebrate animals, where the lungs become cellular sacs (amphibia), or are replaced by gills (fishes), and where we may presume it a matter of still greater moment to economise the arterial blood that is formed, there is an extension of the same system of circulation to the kidneys, which, in the two higher classes of the vertebrata, is limited to the liver.—*G. G.*

organs placed so near the centre as the lungs. The aorta and pulmonary artery mostly divide at acute angles into branches of progressively greater degrees of minuteness, and finally into terminal capillary networks and festoons, or vessels intermediate to the arteries and veins properly so called. Both aorta and pulmonary artery consist of three layers or coats: 1st, an internal serous coat (§ 126 and § 128) covered with a simple epithelium, which frequently passes over into a cellulo-fibrous variety of epithelium, which in the capillaries seems often to constitute the sole boundary of the canal; 2d, a middle, and in reference to the diameter of the artery, a thick tunic of elastic substance (*fig.* 55), which surrounds the vessel in several layers, and is the principal element which gives to the artery its strength and distinguishing elasticity; 3d, a cellular external tunic which surrounds the vessel and connects it with the parts in the vicinity (*fig.* 50).

The pulse is produced by the sudden increase in the quantity of blood contained in the arteries which is effected by each contraction of the left ventricle and the consequent expansion of the blood it contained. The wave of blood once pushed into the arteries, the stream is kept up by the elastic force of the vessels themselves, which suffices to carry it to the entire periphery of the body. The elasticity of the arterial parietes acts precisely in the same way as the air-cistern in such an hydraulic machine as the fire-engine, in which, though the stroke is only given at intervals, the stream is still sent forth without interruption, though it may be with jerks or increased impetus at the moments of renewed force;

in the ultimate divisions of the arterial system the blood flows in one continuous and even current. The stroke of the heart itself against the walls of the chest depends on the push forward of the entire mass of the organ raised upon the great arterial trunks which its action has just filled to the utmost, and given a tendency to assume a straight line instead of the curved one which they present when partially filled or empty. The arteries generally run deeper in their course than the veins, and when divided do not collapse like these vessels; on the contrary, they continue rounded as before. The arteries taken all together may have a capacity about half as great as that of the veins.

§ 296. The pulmonary artery conveys venous blood; it divides into branches along with the bronchi, and forms delicate capillary reticulations around the pulmonary vesicles (*fig.* 145, very highly magnified, *figs.* 213 and 159). At its origin or commencement in the right ventricle, the inner membrane of the artery forms the semilunar valves (*fig.* 121), which are fashioned very much in the same manner as the valves of the trunks of the veins (*figs.* 114 and 116, *f*, *f*, and *g*, *g*), save that they are three, not two in number, and, by reason of the quantity of elastic tissue they inclose, considerably thicker and firmer. The root of the aorta is guarded precisely in the same way. The semilunar valves prevent the regurgitation of the blood, just thrown from the ventricles of the heart, back upon the cavities during the interval of their diastole, when they are in a state of relaxation and themselves getting filled with a fresh supply of blood from the fountain of the venous sinuses and auricles.

§ 297. With any interruption of the breathing, the circulation of the blood in the periphery of the lungs suffers a pause; and the interruption continuing, the stasis extends to the pulmonary artery; the right ventricle, the right auricle, the venæ cavæ, and the veins generally of the greater circulation, then become congested with blood, and so remain till life has fled. In those, therefore, who have died from suffocation—drowning, hanging, &c., the whole mass of blood is venous, and is contained in the arteries of the lesser, and in the veins of the greater, circulation.

§ 298. Should any bodies larger than the blood-discs enter the veins or the lymphatics, they are sure to be arrested in the capillaries of the lungs, when they give rise to exudations of the plasma or liquor sanguinis through the parietes of the vessels into the pulmonic tissue and the formation of tubercles.*

§ 299. The aorta arises from the left, as the pulmonary artery takes its origin from the right, ventricle of the heart; its semilunar valves are stronger than those of the pulmonary artery, and the Arantian bodies in the middle of their free edges are larger and more distinct. The aorta shortly after its origin begins to form an arch towards the vertebral column—the arch of the aorta—from which in man three vessels, in the hog and the carnivora two vessels, and in the gramini-

* *Vide* what is said in § 289 and the accompanying note.

vorous domestic mammals a single vessel, arise to supply the head, neck, and thoracic extremities. The aorta from the arch onwards has different names in different parts of its course,—the thoracic aorta, and the abdominal aorta—and supplies the trunk, the thoracic and abdominal viscera, and the inferior or abdominal extremities with blood. Where branches come off from the main trunk, it is common to observe an infundibuliform enlargement to facilitate the entrance of the blood. This arrangement is particularly conspicuous at the origins of the intercostal arteries.

It rarely happens that anastomoses or communications take place between arteries of considerable size; we have exceptions to the general rule, however, in the communications of the cerebral with the vertebral arteries, and of the cerebral arteries with one another in front of the pituitary body to form the circle of Willis. We have also the vascular arches of the mesentery formed by the communications of the large branches of the mesenteric arteries. The arteries advance tortuously in parts that are subject to enlarge upon occasion, as in the uterus; sometimes the tortuous course appears to be instituted for the purpose of retarding the blood, in the testes for example.

When the arteries have reached the organs for which they are destined, they subdivide into branches and minuter twigs, which generally inosculate freely. The vessels that proceed from the last of these inosculations form the peripheral or capillary networks which themselves end in the veins.

§ 300. The peripheral portion of the sanguiferous system presents itself under a variety of appearances, as a glance at the figures from 122 to 135, and from 137 to 152, will render obvious. In general, it bears a close resemblance to the peripheral expansion of the nerves of the corresponding part of the body, inasmuch as the terminal plexuses of the nerves form a more or less continuous and closed rete, the meshes of which inclose similar meshes of the capillary arteries.* The terminal loops of the nerves are also accompanied by very similar terminal loops of the arteries or intermediate capillary vessels.† Even the particular forms of peripheral nervous distribution have their analogues in the peripheral vascular system.‡

The capillary vessels (*fig.* 6, A, *b*, *b*, *b*; *fig.* 21, *e*, *e*, *e*) are the medium of transition from arteries to veins, and they form either simple nooses (*fig.* 6), or they run tortuously (*fig.* 21), or they form various meshes, or convoluted rete mirabiles (*figs.* 151 and 152). Such varieties of terminal distribution of arteries as are sketched in *figs.* 122–135 have been specified.§ In the skin and mucous mem-

* Compare the peripheral distribution of the nerves (*fig.* 93 at *b*, *b*, *figs.* 95 and 106) with the vascular networks (*figs.* 144, 145, 150, and 213).

† Compare the terminal loopings of the nerves (*figs.* 97 and 98) with those of the arteries (*figs.* 124, 125, 126, 127, and 137, 138); further, the compound nervous papillæ (*fig.* 93, *d*, *d*) with similar convoluted tufts of vessels (*fig.* 139).

‡ Compare the convoluted nervous papillæ (*figs.* 99 and 100) with the erectile vessel (*fig.* 119) and the Malpighian body (*fig.* 152).

§ *Vide* explanation of these figures.

branes these simple and compound festooned or looped vascular arrangements are always the more remarkable the more sensitive and active the parts are.

The capillary nets are here and there so thick that when completely filled, the intermediate spaces almost disappear (*figs.* 146 and 148). The parietes of the larger vessels, such vessels, namely, as are still visible with the naked eye, have their own vessels and capillary nets as well as other organs (vasa vasorum), and are surrounded by nervous loops which for the most part belong to the organic system. The branches, too, are surrounded by fine networks of absorbents which seem to belong to them in especial.

In many parts of their periphery the arteries compose what have been called wonderful nets—retia mirabilia—of different forms; these are intricate, tangled reticulations of vessels.* Of the ball-shaped retes just referred to, there are many varieties, one of which, of a more flattened form, from the thyroid body of a child, is represented in *fig.* 146. J. Müller discovered a peculiar form of the arterial branches in the erectile organs, which he has characterised under the name of *helicine*—arteriæ helicinæ. These are spirally wound varices, which now appear to end in blind sacs, and again to advance as branches of smaller diameter, or to pass over into venous branches (*fig.* 155); it is

* Vide *fig.* 151, which is from a peripheral rete of the supra-renal capsule of a child, after Berres; and *figs.* 152 and 153, after Krause; and *fig.* 154, in which Malpighian bodies from the cortical substance of the kidney are represented.

not likely that they end as blind sacs at any time. With the complete injection of these helicine arteries, the bulk of the erectile organs, as of the penis, increases somewhat; but proper erection only ensues upon the filling of the erectile veins (§ 306). In textures, which consist of parallel fibres and filaments, the muscles for instance (*figs*. 141 and 142), the minuter subdivisions of the arteries also run, for the most part, parallel between the fasciculi.

§ 301. The capillary arteries are not seen every where to pass directly into veins; they have been supposed sometimes to form independent loops, particularly in the placenta, many of these departing from common pedicles or stems, and expanding into tufts or pencils (*figs*. 134 and 135). This kind of termination, however, is more than doubtful; the structure indeed exists, but the loops very certainly revert and anastomose with other arterial loops, or, after making a turn or two, they end in veins.

§ 302. The portal vein, the trunk of which is formed by the vessels which return the blood from the various chylopoetic viscera, is obviously assimilated to the arteries in the mode of its distribution through the liver, its peripheral expansions ending in the hepatic veins.

Veins.

§ 303. The veins return the blood from the periphery to the heart. They arise as capillaries of the finest description from the capillary vascular retes in every part of the body; but even in their origins they are larger than the arteries at their terminations, so that wherever the arterial and venous retes form distinct strata, the one is readily distinguished from the other (*fig*. 144). The veins unite into finer and then into larger branches and trunks, which are always both of greater diameter and more numerous than the corresponding arteries.* This is evident when we see every artery of the extremities so constantly accompanied by two veins, each of larger calibre than itself, to say nothing of the large veins which we find running in many places altogether unaccompanied by arteries,—the subcutaneous veins of the arm for example. The unions between the branches of veins occur for the most part at larger angles than the divisions of the arteries. The veins are by no means so uniformly cylindrical as the arteries, they are often irregular and knotty, and this not merely because of the occurrence of their valves, but from their being actually of different diameters in different parts of their course. Some veins seem even to have what

* In a given length the veins seem to contain about four times as much blood as the arteries; supposing the blood to flow with equal rapidity in both veins and arteries, consequently, about four times as much would pass through the veins in a given interval as through the arteries: or otherwise, suppose equal quantities of blood to be transmitted through each order of vessels in the same period, the motion must be about four times more rapid in the arteries than in the veins.

It is very commonly supposed that the sum of the capacity of the branches of an artery in a given portion of their length is larger than that of the trunk from which they are derived. An experiment which I made upon the mesenteric artery would lead me to say that there was no perceptible difference in this respect; a certain length of the branches held as nearly as possible the same quantity of injection as the same length of the stem.

may be called normal dilatations or varices, which, under the influence of pressure by neighbouring muscles, assist the circulation in the same way as the lymphatic hearts of reptiles; this is remarkably the case in the facial vein of the horse.

The veins, from the thinness of their coats, are transparent; when empty they collapse; during life and when full of blood, they are much more readily compressed than the arteries; the pressure exercised upon them, indeed, by neighbouring muscles is a means of assisting and accelerating the circulation through them.

In spite of their thinness, the veins nevertheless consist, like the arteries, of three coats; but the structure of the middle one of these is different. In the veins it is not composed of elastic tissue as in the arteries; it is, on the contrary, made up of fibres of fine organic muscular or contractile tissue, which run in long spirals, and under appropriate stimuli, both contract the diameter of the vein and diminish its length.

§ 304. The valves of the veins are observed either in the course of their canals or guarding the inlets of such branches as join them.

1st. The valves of the stems are of the same essential nature as those that guard the commencements of the aorta and pulmonary arteries, and that occur in the interior of the lymphatics. They are formed of duplicatures, or loose folds of the internal tunic, between the component laminæ of which contractile fibres are interposed. These valves are not observed in the great venous trunks, and do not exist at all in the veins of the lungs, in those of the liver and glandular organs generally, and in those of the brain; neither are they met with in the minuter subdivisions of the venous system in any part. In the larger veins the valves are double, and in opposition to one another (*figs.* 114 and 116, *f, f*); they are rarely threefold; in smaller veins they are simple, so that the free edge of the valve flaps against the opposite wall of the vein when it closes. From the structure and mechanism of the valves it is obvious, that whilst the current of the blood is free and unopposed by them when it sets in one direction, it immediately brings them into play, and causes an entire obstruction of the vessel should it by any force or accident acquire a disposition to move in the opposite direction (*figs.* 114–117, and explanations).

2d. The valves that guard the inosculations of veins with one another are very regular in their occurrence. They are formed variously: sometimes the smaller vein extends for a certain way into the larger (*fig.* 114, *d*, *e*); sometimes the fold of the inner membrane which lies in the angle of junction enlarges so as to overlap the mouth of the entrant vessel in case of need. When the pressure in the stem becomes greater than that in the branch, the semielliptical fold (*fig.* 114, *d* and *e*) is then pressed against the opposite outer wall of the branch (*fig.* 116, *d* and *e*), and the return of the blood is prevented. The same form of valve also occurs at the entrance of lymphatics into veins, and at the points of junction of lymphatics with one another. We observe the same contrivance used to defend the extremities of the ureters against the reflux of the urine from the bladder, and the terminations of the salivary glands in the mouth, against the regurgitation of saliva or other fluids.

ERECTILE VESSELS AND ERECTILE ORGANS.

§ 305. When speaking of the contractile tissue (§ 241), it was stated that the erection of the erectile organs was, at least in part, owing to a kind of spasm of this tissue. This view is made the more probable on account of the regular occurrence of the peculiar contractile tissue in all erectile organs. The motions of the iris depend, in all likelihood, on the agency of the same kind of tissue.

The erectile organs consist in great part of a venous rete, with relatively very small interspaces, which are occupied and traversed in all directions by arteries, nerves, contractile fibres, and by elastic, fibrous, and cellular tissue.

§ 306. *Erectile Vessels.*—There are two peripheral forms of arteries known which seem to deserve this name,—the tendril-like or helicine arteries, and the arterial retia mirabilia (§ 300). The vessels, however, the distension of which principally effects the turgescence and erection of erectile organs, belong to the peripheral venous system. These vessels are without valves, and are, as might be presumed, particularly developed in the male external organ, and in the female clitoris. They are also very distinct in the spleen. The labia minora in the female are erectile organs, but in an inferior degree; so are the nipples in woman and female animals generally. The structure of erectile organs, wherever they occur, is essentially the same. In the penis the erectile veins are distinguished into external and internal; the former compose the glans and corpus spongiosum urethræ in great part, and are in communication with the dorsal vein of the member (*fig.* 118). They are short, knotted vessels which anastomose very freely with each other, and when filled leave no spaces between them. The veins emerge, for the major part, from the glans upon the dorsal aspect of the penis, and unite into branches that constantly become larger and fewer in number, until they finally compose a single trunk,—the great dorsal vein. The internal erectile veins are inclosed by the strong fibrous tunic of the corpora cavernosa penis, and form the greater portion of its body. They present themselves under two forms, which, however, are only distinguished from one another by this, that in the one the branches are somewhat tortuous and interlaced and form a connected rete, yet of such a kind that the larger stems run parallel to one another, but connected by numerous transverse canals, in the long direction of the penis; whilst in the other the vessels look like coils of small intestines chiefly disposed transversely through the body of the organ; vessels of this description are very remarkable in the great enlargement which occurs towards the anterior third of the penis in the dog during the sexual act (*fig.* 119). In the clitoris the veins are of the same kind as in the penis. The mode of distribution and of peripheral termination of the splenic veins bears a considerable resemblance to what we observe in glandular organs. The veins at their peripheries expand into pediculated vesicles, something in the same way as the final divisions of the bronchial tubes (*fig.* 120); and these, precisely like the air-cells, are surrounded by a very delicate vascular rete. The veins of the spleen, like those of the penis, communicate very freely with one another.

§ 307. The reticulations formed by the large veins of the erectile organs are penetrated in all directions by the web of mingled tendinous and contractile tissue which is sent off from the general investing sheath, and by the arteries which at innumerable points end abruptly in veins from ten to thirty times their own diameter; frequently, however, forming fine retes upon the veins, and, in the hinder portions of the penis especially, falling into the tendril-like or helicine form of artery. These helicine arteries are rarer in the clitoris, and are not so well developed as in the penis.

The spleen, like the male organ, is penetrated in all directions by a reticular fibrous tissue in connexion with its general outer investing tunic. The spleen is beyond all question an organ susceptible of various degrees of injection with blood, and, therefore, of *distension;* but it is not an erectile organ in the same sense as the penis or clitoris; this, however, happens rather from the manner of its attachment than from any difference of structure. Were the spleen implanted upon a bone, it would upon occasion, and with any impediment to the return of its blood, become *erected* instead of being simply *distended.*

§ 308. *Erectile Organs.*—So long as the blood flows unimpeded out of the erectile organs, they continue flaccid; but with any impediment to the backward current of the blood, the flow by the arteries continuing as before, they become distended and erect. The nerves, surrounded by a larger quantity of blood, now become more sensitive. The erection, indeed, seems to depend immediately upon the state of the nervous system, being accomplished by the agency of the tonic contraction or spasm of the muscles and contractile fibres in the tissue. This spasm, as regards the male organ and the clitoris, only yields with the completion of the sexual act, when these organs fall flaccid again. But in those who have died by hanging and by decapitation, a certain degree of erection has sometimes been observed to remain for hours, and even for days after death; this, however, is no vital act, but follows from the stiffening of the entire system of voluntary motion, by which the blood is retained in the organs into which it had been forcibly injected.

It would seem that neither the more rapid action of the arteriæ helicinæ, nor the repletion of the venous rete of the corpora cavernosa in consequence of this, nor the action of the ischio-cavernosi muscles, nor yet the compression of the dorsal vein against the symphysis pubis, are competent to produce erection of the penis, although each and all of these acts contribute, and are indeed essential to the effect; but that it is principally and more immediately dependent upon the agency of those reddish fibres and fasciculi, which I regard as *contractile tissue*, which enter into the structure of the organ. I have already had occasion, oftener than once, to mention this tissue as presenting itself in the composition of the scrotum, where it is known under the name of the *dartos,* of the nipple, of the skin in general, and of the iris; and which appears every where to stand in a peculiar and especial relationship to the nervous system.

The elastic tissue that surrounds the erectile organs is the active means employed for emptying these, once the erethism, under which the injected condition was accomplished, has passed away.

§ 309. It was my intention, in this place, to have given my views on the nature of inflammation, its causes, ends, and consequences; but this I find I cannot do without exceeding the proper limits of my work. There is one morbid phenomenon, however, of frequent occurrence, both in the human and animal body, which presents itself with and without inflammatory symptoms, but in intimate connexion with the capillary vessels which I shall touch upon as briefly as possible before proceeding to speak of the origin of the blood-vessels. The morbid phenomenon to which I allude is the

FORMATION OF TUBERCLE.*

§ 310. Various and very dissimilar causes may bring about coagulation of the concrescible fluids of the body,—the chyle, the lymph, the blood, and some of the products of glandular secretion. Among the number of these causes may be reckoned: loss of the solvent medium, particularly the water (§ 23);

* Concerning the Structure of Tubercle, see Mr. Gulliver's figures 252, 253, 254, 255, 270, and 271, and his observations in Appendix.

greatly retarded motion or absolute stasis; the admixture of chemical reagents absorbed along with the chyle, the lymph, &c., such as acids, salts, pus, mucus, ichor, &c., or that penetrate from neighbouring parts in virtue of the law of endosmose. To these must be added mechanical causes, injuries of all kinds, pressure, bruising, solution of continuity; and farther, the influence of unusual temperature,—exposure to excessive heat, severe cold, &c.

§ 311. Should the diameter of the particles of coagulum, however produced, be greater than that of the capillary vessels of the lymphatic, sanguiferous, and secretory system, they will become impacted in the capillary rete (§ 289 and 290) and stop this up; or, otherwise, should the capillary vessels be injured in any way, should they become compressed by extravasation around them for example, then may the pure blood itself suffer obstruction. In this way a local stasis is produced in the blood-vessels betwixt the part implicated and that at which the circulation is carried on by collateral branches and anastomoses, in the lymphatics and lacteals betwixt the glands and the periphery connected with them. It is easy to see, therefore, why the lymphatic glands, the lungs, and the liver, are so commonly the seat of tubercular depositions. The coagula first reach the capillary vessels of one or other of these organs, and there get set fast as a matter of course. The fluid that has passed unimpeded through the pulmonic circulation, in particular, will not be apt to encounter any impediment in the course of the greater circulation, unless perchance it be in some injured part.

§ 312. The consequence of any accumulation of fluids in a particular part is an increase of pressure upon its vessels, in the same proportion as the transmission of the fluids is impeded; and then the distended parietes of the vessels suffer the more liquid elements of the compressed fluids to transude and to accumulate in the surrounding tissues, in which, according to their nature, they either coagulate or form precipitates, the serum which is set at liberty being then absorbed by neighbouring vessels. In this way the concrescible and more or less organisable elements of the general circulating fluids accumulate locally, whilst the watery parts increase relatively within the circulating system; the consequence of which is, that the general nutrition of the body suffers, that the vital functions at large are depressed, and that the predominating serum overwhelms, as it were, the enfeebled organs of secretion, and finally, the serous cavities; the interstitial and subcutaneous cellular substances then get filled, and general dropsy comes to be associated with the local disease. This state of things may go so far as finally to interfere with the performance of the whole of the offices most essential to life, if the individual is not cut off by the particular implication of such an important organ as the lung or the brain.

§ 313. Tubercles present great variety in respect of numbers, constitution, extension over several systems or limitation to one, &c. The exudation takes place either into the tissue of the part implicated, or its deposition causes compression of this and wasting through want of due nourishment. Tubercles are conveniently divided, according to their constitution, into *albuminous* tubercles, *fibrinous* tubercles, and tubercles of a *mixed nature.*

§ 314. I. *Albuminous or Unorganised Tubercles* can only be produced from exudations abounding in albumen, poor in fibrine. They consist almost entirely of granules from the $\frac{1}{1000}$th to the $\frac{1}{200}$th of a Paris line in diameter; but with the granular matter, nucleoli, nuclei, or cells, are mingled in quantity bearing relation to the amount of fibrine which the exuded fluid contained. In man the lymphatic glands are the common seat of these albuminous tubercles, and often attain the size of a walnut and even of a hen's egg. In our larger domestic animals they are sometimes seen as large as a child's head. They are of a greyish white or of a pure white colour, firm, but seldom fibrous; they are subject to softening and solution, when they form a mixed compound of granules, cyst-corpuscles, and serum, with a few cytoblasts, the product of the living tissues around the tubercular mass, this being in itself incapable of suppuration; sometimes this external layer of purulent matter is so abundant that the tubercle lies loose like a seed within its husk. What may be called *false albuminous tubercles* also arise occasionally within the substance of the secreting glands, in the granular degeneration of the kidneys, for example. In the earlier stages of this disease indeed, the albumen is deposited in the tortuous uriniferous canals of the cortical substance; in the fully-formed disease, however, it is met with among and between the tissues also. The albuminous or granular tubercle is with great propriety often spoken of as the *scrofulous tubercle*, the disease being especially developed among scrofulous individuals.

§ 315. II. *Fibrinous Tubercle.* — The plastic exudations from the blood-vessels into the different softer tissues, which take place in consequence of impediments to the flow of the blood through the capillaries, produce fibrinous and organisable tubercles in the event of reabsorption not immediately occurring, or true purulent abscesses when the oxygen of the atmosphere finds immediate or mediate access to the deposit. Tubercles of this description, according to the circumstances under which, and the time during which, the exudation has taken place, the vital condition of the individual and the constitution of the organic part affected, present important varieties, which include every conceivable difference between the substance of any recent plastic exudation and that of a complete internal cicatrix. Taking degree of organisation as the basis of a division, we may distinguish —

1. *The Hyaline Tubercle.*— This form is found, with traces more or less distinct of mingled cytoblast formations, in the bodies of those who have died during the period or very immediately after the occurrence of copious plastic exudations; it is rarely seen, from the rapidity with which it passes into

2. *The Cytoblast Tubercle,* in which nucleoli and naked cytoblasts at first appear; with the

completion of the process of formation of the cell-germs, however, the tubercular deposit appears to consist entirely of these last, and of an interposed hyaline substance. When this organisation has gone a stage farther, the deposit may be entitled

3. *The Cell-tubercle*, the cell-germs or cytoblasts having now undergone transformation into cells.

4. *Cellulo-fibrous Tubercle.*—When the exudation is very abundant and proceeds with great rapidity, with condensation of the surrounding tissues, it is only organised where it is in contact with the living sides of the cavity which has been formed. The periphery of the deposit in these circumstances forms an organised sac, inclosing a central mass, in which the organising process does not go beyond the formation of cell-germs or cytoblasts. From this the serum is either absorbed, and the cytoblast tubercle, become a dry mass, remains for an indefinite period in this state, or if absorption does not take place, it runs speedily into suppuration. The dry cytoblast-tubercle, however, is never secure against suppuration; sooner or later, and as a consequence of a secondary effusion of serum, it softens, and may then suppurate. When the exudation takes place slowly, so that the tissues are merely infiltrated without being displaced and compressed, or when the tubercles are small, so that their central point is not too far removed from the healthy tissue around, the cytoblasts or cell-germs proceed in their evolution and become cells, which arrange themselves into fibres, and so form an imperfect cicatricular substance, a cellulo-fibrous tissue, which increases

the density of the organ in which it is deposited, but which may go on for many years unchanged, and causing little or no derangement of function.

5. *Filamentous Tubercle, Cicatricular or Organised Tubercle.* — This structure is only produced under favourable circumstances in connexion with very slow infiltration of tissues with plastic exudation, and the organisation of this into more or less complete filamentous formations. If an exudation of this nature has happened equally into the substance of a considerable portion of a soft organ, such as the lung, for example, we have then general condensation of the tissue, termed variously hepatisation or induration; if it have been more local, we have circumscribed induration; and if the indurations be small and have occurred in different places simultaneously or successively, we have organised tubercles. All such parenchymatous cicatricular formations interfere in a greater or less degree with the functions of the organ in which they occur; but if the exudation does not continue, they commonly remain for long periods of time without undergoing change; they seldom soften, and without repeated exudations around them they cannot be brought to suppurate.

The substance of tubercles is sometimes intermingled with pigmentary granules, cells and cellular fibres, like melanotic formations in general,—these constitute *melanotic tubercles.*

§ 316. Granular, cytoblast, and cell-tubercles, more rarely fibro-cellular tubercles, may all soften and become diffluent. This change must not, however, be confounded with suppuration; for, instead of forming proper abscesses, they become changed into cysts filled with diffluent inorganic contents; or they give rise to internal ulcers with a kind of gangrenous implication of the surrounding tissues (§ 289 and 290). They only suppurate when the air of the atmosphere has access to them, either more immediately, as when they are laid open, or mediately and by penetration, as when they are deposited in the lungs and near the surface beneath the skin.

Origin of the Blood-vessels.

§ 317. Although the ovum, both at its own formation and during the earliest stages of the process by which a new being is produced, advances without the assistance of vessels (§ 123), still this is only so long as the process of developement consists in the formation of cells and the arrangement of these into the rudiments of the principal systems. The rudiment of the sanguiferous system itself is produced as a necessary preliminary from the cellular mass of the intermediate or vascular lamina of the embryo (§ 123). Whenever the formative process has to get beyond the simple arrangement of cells, in which it has hitherto consisted, and these cells must undergo transformation into the parts of dissimilar tissues, blood-vessels and blood become necessary, precisely as we observe to be the case in regard to secondary organisations (§ 82, 88, 111).

The heart arises first as a simple excavation in the cellular mass of the vascular lamina; the blood-corpuscles then appear, and at the same time the sacculate parietes of the heart, and by degrees the vascular arches and the entire circulating system of the periphery or of the membranes.

The sanguiferous system in the fœtus consists at first of a single loop, as it were: in the young embryo of the fish, for example, a single canal without branches takes its departure from the heart along the vertebral column, turns round at its extremity, and returns as a venous current to the heart. From this loop new ones proceed inwards and outwards, and around these the already existing mass of cells becomes more highly organised, and others arise, betwixt which the formation of vascular loops continues to proceed with the same effects; in this way the embryo grows and attains its developement, its vascular system at the same time increasing continually, each element supporting the other, for without pre-existing cells no blood-vessels are formed, and without blood-vessels no parent cells.* From the first loops the principal trunks are formed, from the next in order the secondary trunks, from those still later the branches, and so on, every blood-vessel advancing in its evolution with that of the organ to which it belongs, or of the organism at large of which it forms a part;—the principal trunks were themselves originally capillary vessels.

The primary capillary retes are variously formed during the general developement, but they seem to

* Blood-vessels only arise between or among cells, never in parts of higher formation, for example in tissues; if they arise secondarily in these, it is only after a preceding fresh formation of cells.

increase in dimensions commensurately with the increase which takes place in the organs that include them; should the organ expand in all directions pretty equally, the original vascular rete will be found expanded in the same manner, as for example in the bones of the skull (*fig.* 66); should the organ, on the contrary, increase, especially in one direction, the vascular rete will be found elongated in the same degree, as it is for instance in the middle portions of the long bones (*fig.* 61).

§ 318. The vessels themselves, in all probability, arise out of the newly formed intercellular substance in the same way as the white tubular fibres of the nerves and the branched pigmentary cells. Of the mode of origin of these and of their relations to the capillary vascular system, Schwann* has particularly spoken. Certain special cells are produced, which are first arranged into cellular fibres, and then becoming fused together form hollow tubes. The mode of origin of the blood-vessels can be followed in the formation and developement of the vessels of bone in the course of the process of ossification.

In examining the injected and dried cartilage of the ear of a new-born foal, I could not determine whether the capillary retes, which were visible in different places (*fig.* 213), belonged to the investing membrane, or to the substance of the cartilage itself; probably they belonged to the perichondrium; such close networks are not commonly seen in permanent cartilages. Any thing like close capillary retes first make their appearance with the

* Mikroscop. Untersuchungen. S. 182.

commencement of ossification in the ossific cartilages.* Whilst the cartilage-corpuscles disappear in the bone-producing cartilages of the fœtus, a blended fibrous tissue arises, and within this nuclei and bone-cells, isolated and connected into strings, which arrange themselves concentrically around the cavity of the nascent bone-vessel (*fig.* 65, *b*).

Whilst the cartilage-corpuscles are disappearing in the embryonic cartilage, and it is becoming a continuous fibrous tissue, a vascular network makes its appearance within it, the first rudiments of the new formation being evolved in the primary intercellular substance, and consisting of connected delicate fibres. Upon these fibres bone-cells are deposited. The rudimentary vascular rete thus produced is isolated at first from other similar formations and unconnected with any actual blood-vessel; but by degrees one gets into communication with another, and then with some vessel in its vicinity, blood begins to flow through the reticulation, and the structure is completed. From the crown of the outermost vascular arches thus formed, branches or leaders are sent off, at first in straight lines, but which soon bend round in

* I must here refer to my most recent observations on ossification (§ 179 and 184), which I imagine remove all doubts of the bone-corpuscles being the nuclei of my bone-cells (§ 184), at the same time that they shew either that the medullary canaliculi, as they are called, do not exist as such, or that other cavities to which such an appellation is inapplicable have often been taken for them. Kobelt of Heidelberg, at the meeting of German naturalists at Freiburg in 1838, shewed preparations that confirmed these views. I have also been able to fill the finest vessels of the bones by injections thrown into the nutrient artery in the human subject.

one direction like hooks, until they encounter and join; each new arch produced sends off new shoots, which again bend round and meet their neighbours as before, and so the process goes on, and with it the formation of the bone. These shoots, when they first appear, are rounded, blunt, and closed at the extremities. Around the delicate vessels thus formed, flat bone-cells are deposited incessantly, by which the bony interspaces become thicker and stronger, and the vascular canals, on the contrary, are reduced in diameter. The vessels are readily distinguished in the midst of the bony reticulation (*fig.* 213); the delicate fibres and filaments that were first formed are seen projecting from the edges of fresh bone when broken. When cut transversely across, the tubuli display their concentric layers of bone-cells (*fig.* 65, *b*). At this point of the ossific process some cartilages remain stationary, and even in some of the softer parts of proper bones it goes no further,—at the ends of the medullary cavities of the long bones, for example. In the compact bones, however, it proceeds, for the meshes or spaces between the bony fibres get filled up with rounded bone-cells (*fig.* 60, *i*).

Secreting Vessels.

§ 319. The secreting vessels are in one case branched sacculate involutions of the mucous membranes which proceed from the mucous lamina, or of their epithelia; in another they are similar involutions of the corium or its epidermis. As their purpose, so is their mode of origin different from that of the general circulatory vascular system.

They terminate, as a general rule, at their periphery in blind pediculated vesicles into which the peculiar secretion distils or percolates from the blood that is circulating in neighbouring vessels, and from which this is conveyed to the place of its destination or of its excretion; the principal trunks of secreting vessels are spoken of as *ducts* of the glandular parts with which they are connected. They form the most essential and distinguishing element of secreting glands.

Evolution of the Mucous Cavities from the Mucous Lamina in the Embryo.

§ 320. The mucous or inner layer of the germinal membrane separates, as is well known, first from the serous and then from the interposed vascular lamina. By and by, along with the embryo, it is gradually pinched off from the vitelliculus or yolk-sac, which thus becomes divided into two cavities connected with one another. The smaller of these cavities, in connexion with the abdominal aspect of the embryo, furnishes the rudiments of the future mucous system. At first it presents no more than a simple nutrient cavity, as in polyps; but out of this, one after another, by evolution and involution, separation and outward opening, the various mucous cavities and the secreting organs lined with mucous membranes are evolved. The mucous system at large may be viewed as a chemical apparatus superadded to the mechanical system of muscles, bones, ligaments and cartilages, and to the dynamic one of the nervous system, by means of which the necessary interchange of matter and the material relations with the external world are accomplished. The elongated intestinal chink, which is at first widely open towards the yolk-sac, closes anteriorly and posteriorly into blind sacs, — the rudiments of the mouth and anus; and with advancing evolution, the middle portion is closed likewise and forms the small intestine, which, however, still continues in communication with the yolk-sac by means of a narrow canal — the vitellicular or umbilico-vesicular duct. In the mammalia this is speedily closed and rendered useless, its place being, at a very early period, supplied by the umbilical cord or vascular bond of union betwixt the parent and the embryo, the medium by which nutrient juices are brought for its use, and by which effete matters are removed from its economy. The intestinal communication with the mouth is first established, and then that with the anus. The intestinal canal is at first of large capacity and only of the length of the vertebral column; it becomes relatively narrower in diameter by degrees, and is constantly growing absolutely longer. The simple intestinal tube consists at first of connected cellular filaments, so that it appears evenly granular when viewed under a suitable magnifying power; it is only by and by that the muscular can be distinguished from the mucous tunic.

In the head the intestinal tube enlarges to form the fauces, and under the diaphragm to become the stomach, which lies at first transversely from left to right in the shape of the letter S, and forms a right angle with the œsophagus above, and with the small intestine below. In ruminating animals it is divided by two constrictions into three cavities, the middle one of these being the largest. The small intestine is finally completely separated from the yolk-sac or umbilical vesicle. During the time that the beginning of the great intestine lies in the umbilical sheath and yet unincluded within the cavity of the abdomen, the rudiments of the cæcum appear. Near the posterior extremity of the still closed intestinum rectum, the allantois or urinary pouch has been produced at an early period.

Origin and Evolution of the Glands, whose Ducts are lined with Mucous Membranes.

§ 321. Besides these simple evolutions as means for the production of simple cavities, only one of which accomplishes its ends with the period of birth, and therefore disappears, — the allantois, — the ramified secondary cavities grow from the intestine, looking at first like blind lateral divarications from this; but the chief canal, still branching off in determinate directions until the skeletons of the compound mucous glands, and those of the urinary and genital systems, of the lungs, liver, pancreas, &c. are evolved. The mucous canals of these last, getting finer and finer as the ramification extends, increase with the peripheral expansion of the sanguiferous vascular nets that play around them, the two elements growing together out of the mucous and vascular systems, but always amidst the gelatiniform, and at present scarcely recognisable cellulo-fibrous substance which had been prepared beforehand for their reception; in this way the destined limits of the gland are finally attained. The lymphatics and nerves of the glands are evolved at the same time; and finally, from the still interposed but hitherto indifferent cellulo-fibrous tissue, the connecting cellulo-filamentous tissue. In the same way do the cutaneous glands, particularly the mammary glands, also commence and proceed in their developement, their ducts or skeletons and most essential parts being formed by a succession of ramified involutions of the corium.

§ 322. This mode of developement of the compound secreting glands from the central parts to the periphery, is in nothing analogous to the mode of origin and extension of the blood-vessels in the more persistent, though still transition cellular formations; for example, in the bone cartilages during the period of their ossification (§ 318). Nevertheless, even as we observe the central and peripheral portions of the vascular system arising independently in the cellular primordial mass of the area pellucida, so do we in some instances observe what may be held as central and peripheral portions of the same mucous system, arising and attaining a certain degree of completeness before they meet and become fused,—the secreting parts of the kidney and testis, for example, and the excreting parts, consisting of the ureters, vas deferens, vesiculæ seminales, &c., meet when they are severally well advanced in their developement. This is obviously very like what we see occurring in the embryo in regard to the manner in which the great venous trunks of the heart advance to meet the large peripheral veins which have been evolved contemporaneously but independently.

§ 323. The progressive evolution of the mucous vessels takes place by a constantly repeated process of branching, until the destined limits of the gland to which they belong are attained. The size of these branched vessels becomes progressively smaller and smaller to their blind extremities; whilst new ones are forming the old increase, and towards the peripheries of glands the secreting vessels are more crowded and of smaller diameter than they are at the membrane or integument from whence they took their rise, where, indeed, we commonly find a single trunk the representative of the entire series of ramifications which are connected with it.

The Skin and the Mucous Membranes.

§ 324. The skin or common integument invests the whole external surface of the body, and serves individuals as the immediate means of isolation from the rest of creation; it also proves a defence against many mechanical and chemical influences; as an organ of secretion, too, it is in relation with the external media, surrounded by which men and animals exist. The secretions of the skin are the sebaceous matter and the sweat (§ 140 and 144), the constituents of which are water and watery vapour, carbonic acid gas, certain volatile matters cognisable by the sense of smell and different salts. In so far as effete or pernicious substances are thrown off by the skin, it is also a depurative organ. The skin farther absorbs gaseous,* vapoury, and liquid substances from without; and then, in alliance with the lungs, it is the great means of maintaining the body at the proper temperature; and associated with the lungs, the kidneys, and the intestines, in regulating the quantity of water contained in the system. The skin, finally, is the organ of common sensation through the whole of its extent; lastly, its sensibility becoming exalted or modified in certain parts, particularly the points of the fingers, it is the seat of the sense of touch.

The skin consists, 1st, of the epidermis or cuticle (§ 136), with its involuted glands and its evoluted hairs; 2d, of the corium, which, besides numerous nerves of sensation, blood-vessels, and lymphatics, contains a contractile elastic and cellulo-fibrous tissue in its constitution; it also contains the sebaceous glands within its substance, and transmits the ducts of the sweat-glands. The

* Dr. Dalton thinks that air penetrates the solids and liquids of the human body during life ("Bibliothèque Universelle de Genève," t. liv. p. 130); and Professor Burdach is of the same opinion ("Traité de Physiologie," traduit par Jourdan, t. viii. p. 34). But Dr. Davy has given the results of experiments, most of which shew that air susceptible of extraction by the air-pump is not contained in the healthy animal fluids and solids, nor in the pus of abscesses, except when air may have had access to the pus, as in a case of empyema complicated with pneumathorax ("Researches, Physiological and Anatomical," vol. ii. VI. and p. 464). If, as alleged by Dr. Dalton, the drawing in and swelling of the hand, when applied to an exhausted receiver, be caused by the tendency of air contained in the part to escape, how could the common operation of cupping succeed, seeing that the air would issue through the incisions and quickly fill the glass?—*G. G.*

corium is connected with subjacent parts by means of a quantity of lax cellular membrane, in which a large quantity of fat is deposited in health and with food in adequate quantities. As it is in part an organ of animal life, the skin is obviously placed in a kind of antagonistic relationship to the purely organic mucous membranes.

§ 325. The *mucous membranes* comprise the same constituent elements as the skin; these are only modified in quantity and in quality, the mucous membranes standing in a different relation to the organism and to external objects from the skin. The peripheral indusium of the mucous membranes or epithelium, kept constantly moist, is softer and less horny than the epidermis; their glandular inversions — the mucous crypts and mucous glands (§ 166–168) — instead of unctuous matter secrete mucus; there are no proper sweat-glands, although it must be allowed that in the submucous cellular tissue we do here and there observe involutions that differ from the ordinary mucous glands, and approach the sweat-glands in appearance. The papilliform eminences which are visible in many parts of the mucous membranes, particularly on the surface of the tongue, are covered by corresponding processes of the epithelium. The corium of the mucous membranes is thinner and looser than that of the skin; it forms numerous villi in certain situations for the purpose of extending the surface. The submucous cellular substance contains no fat, and in general connects the membrane with muscular tissues.

The mucous membranes are in relation with matters or fluids secreted from the blood and destined, 1. (*a*) for the maintenance of the individual, such as mucus, saliva, gastric juice, bile, &c., or (*b*) for the continuance of the kind, such as the seminal fluid, the menstrual flux, the ovum in its passage along the Fallopian tube and during its sojourn in the uterus; 2, for the elimination of effete and noxious matters, such as the urine, bile, &c. The mucous membranes are further the organs by which substances adapted for assimilation — meat and drink — are prepared and made fit to be received into the proper interior of the bodies of animals; and by which also that process, the most immediately essential to life in all the higher orders of beings — respiration — is carried on. The mucous or muco-membranous system is therefore one of vast importance; it serves as the grand instrument of the bio-chemical interchange of elements that takes place between the body and the matters external to it, with which it is in necessary relation.

The innumerable villi with which we see the mucous membrane of the intestinal canal beset, are but contrivances to extend the absorbing surface of the organ without adding materially to its bulk; and the involutions of the membrane which we observe in the numerous secreting glands are no other than means to the same end,— the extension of surface,— but with the opposite purpose of abstracting from the organism, particularly from its circulating fluid, certain matters that are either necessary for other processes, or that were prejudicial if longer retained.

Valves of Excretory Canals.

§ 326. The secreting glands are consequently lateral productions either of the skin or of a mucous membrane. They shed the fluids, which they prepare from the blood, either upon the external surface or into a muco-membranous reservoir, from which none of it can return into the gland, in consequence of the existence at the orifice of the excreting duct of variously fashioned muco-membranous folds which serve as valves. The forms of these valves may be reduced to two:—

1. *Wart-shaped Glandular Valves.*—The wart-like or nipple-like enlargement here opposes any pressure back upon the gland with a power which is in the ratio of the surface it presents in comparison with that of the orifice or slit by which the duct terminates. We observe this kind of valve at the terminations of the salivary ducts, of the ductus choledochus communis, of the tubuli uriniferi on the points of the papillary bodies, of the milk-ducts, &c.

2. *One-sided Movable Glandular Valves.*—Valves of this kind are like those of the veins and lymphatics, and like that which guards the foramen Thebesii in the heart: we have examples of them at the termination of the ureters in the bladder, of the seminal canals in the urethra, &c.

It is also very common to observe contractile fibres in larger quantity than usual, and disposed in the annular form around the orifices of the excreting ducts of glands, by which these openings are guarded to a certain extent in the same way as the anus is by the sphincter ani, and the neck of the bladder by its contractile bundle.

Division of the Glands.

§ 327. Something has already been said respecting the division of the glandular system, under the head of the epidermis (§ 169), and an attempt made to present the glands according to their natural affinities in the form of a table (p. 169). What follows immediately may be regarded as an explanation of the table referred to.

The cuticular glands have already been described (§ 139–144 and 166–169). The placenta has not been included among the blood-glands because it would seem, that those vessels only which are destined to nourish this deciduous organ form a connected rete with one another. The umbilical artery and veins which virtually constitute the placenta, cannot always be shewn to have any direct communication with one another; they form terminal tufts made up apparently of blind capillary loops, a structure of the existence of which conviction may be obtained by successful injections of membraniform placentas, such as that of the mare.

The thymus,* strictly speaking, does not belong to the blood-glands, for it scarcely receives more vessels than seem necessary to nourish it. The group of bodies characterised as "doubtful glands" are very different from each other, but are not yet

* There is reason to believe that the office of the thymus is simply to elaborate an additional quantity of nutrient matter at a period when this is most required by the economy. See Appendix.—*G. G.*

sufficiently known to have their places assigned to them in a natural system of organic parts.

Proper Secreting Glands.

§ 328. In his classical work on the intimate structure and formation of glands,* Professor Müller has described and figured these essential parts in the organism of animals with his usual completeness and accuracy. The secreting glands are soft, rounded bodies, of a colour varying from a reddish-white to a dusky-brown, made up of a congeries of secreting, blood, and lymphatic vessels, and of nerves and cellular substance, which, from the blood circulated through them, prepare and pour into their variously shaped reservoirs certain peculiar fluids, which are finally conveyed away and discharged upon the external or upon one of the internal surfaces of the body, by means of an appropriate duct.

The secreting glands are situated now in, now under, the compound membranes, now in the interior of the body, connected with surrounding parts by means of vessels, nerves, and cellular tissue. The degree of their complexity and their external forms are very various; they are all invested with a fibrous tunic, and those that lie in serous cavities have a serous tunic in addition. Their essential and generally branched cavities either end as blind sacs, or as pediculated vesicles, or as loops, in either and every case surrounded by

* "Glandularum secernentium Structura penitiori earumque prima Formatione in Homine atque Animalibus," c. tab. xvii. fol. Lips. 1830.

a network of much more minute blood-vessels, and a scantier accompaniment of terminal loopings generally of organic nerves. The excretory ducts are now simple openings of simple cavities, now canals of great length and extreme narrowness; these consist of the attenuated elements of the compound membranes upon which they terminate, of which, indeed, they are involutions; they are for the most part lined by a tessellated epithelium, seldom by a cylinder-epithelium; they are either simple or ramified, and in some instances run into ample reservoirs, — the gall-bladder, the urinary bladder, the vesiculæ seminales, — in which the product of their activity is stored up until time and circumstance permit or require its discharge.

The secreting glands in a state of health are nearly insensible, in the ordinary sense of that word; they are, however, extremely susceptible of certain appropriate organic stimuli; the seat of this susceptibility appears to be the vessels in general, but especially the contractile secreting vessels (on the origin and relations of these to the tegumentary system, &c. *vide* § 318–323 and 325).

The secreted fluids are watery, or they are unctuous, or of a mixed nature, and contain mingled with them the detached epithelial cells of the secreting cavities. The secreting glands are simple or compound.

§ 329. *Simple Secreting Glands.*—These form small sac-like cavities, and are styled *follicles;* they are contained in the substance of the corium (*fig.* 239, *a* and *b*), or of a mucous membrane. These simple cuticular glands have been included in our account of the epidermis. The lobulated (*fig.* 239, *f*) and multilocular sebaceous (*fig.* 160 and 161), the botryoidal sebaceo-sudoriparous* and the mucous glands (*fig.* 42, *c, d, p, n*; *fig.* 43, *e, f, i, k*; *fig.* 44, *c, d, e*; *fig.* 45, *c, d, e*), strictly considered, belong to the compound glands. When several follicles terminate in the same peripheral cavity, they form with these what are called *crypts.*

§ 330. The *mucous follicles* are flat, lenticular, more rarely elongated and convoluted, and their vascular walls in relation to the extent of the simple cavity they inclose are relatively thick; their simple openings are wide and short; in diameter they range from one-third of a Paris line to three Paris lines, that of their openings being from one-tenth to one-third of the same standard. The majority of them lie in the mucous membrane itself; the larger among them, and those that are convoluted, however, project in part or entirely among the sub-mucous cellular tissue. In general they occur scattered; but in many places they are thickly clustered together.

The mucus secreted by different mucous membranes, and even by different parts of the same mucous membrane, is different,—watery and diffluent here, there thick and tenacious, viscid and slippery, of a greyish or greenish-white colour, and soluble in or miscible with water with great difficulty.

Chemically considered, mucus consists of water in large proportion, proper mucous matter or mu-

* If the sudoriparous glands be found to consist of a single convoluted canal, as Gurlt believes, they must of course be classed with the simple ones.

cine, with a little soda, alcoholic extract with lactates, watery extract with phosphatic salts, and chloride of potash and soda. The microscopic elements of mucus are epithelial cells and mucus-corpuscles, bodies made up of agglomerated granules (§ 35).

§ 331. The *sebaceous follicles* of the skin are, for the most part, present in smaller numbers than the mucous follicles of the mucous membranes. They generally open laterally into the hair-sheaths; they always occur isolated, and are not so universal as the more compound sebaceous glands (§ 139); but they are commoner than crypts. The sebaceous matter is a sluggishly fluent oil, of the consistence of butter, in parts that are not provided with hair, and is either colourless or coloured according to the colour of the part of the skin which it anoints; its colour being in the ratio of the pigmentary granules which it contains. According to Esenbek, 100 parts consist of:—

Fat	24·2
Osmazome, with traces of oil	12·6
Watery extractive	11·6
Albumen and caseine	24·2
Carbonate of lime	2·1
Phosphate of lime	20·0
Carbonate of magnesia	1·6
Acetate and muriate of soda, and loss	3·7
	100·0

§ 332. The *sebaceous crypts* are of different sizes in different parts of the body, and consist of larger or smaller, superficial or deeper blind sacs, included in the skin or mucous membranes, the parietes of which are beset with follicles, which pour the mucus or sebaceous matter into the cavity (§ 142).

§ 333. *Compound Glands.* — When glandular cavities are composed of many smaller ones, simple or ramified, they are spoken of as compound glands. Glands of this order are distinguished into 1, *aggregated* glands; 2, *acinose* or *vesicular* glands; and 3, *tubular* glands.

1. The aggregated or associated glands are mere groups of simple glands or pediculated follicles of various form, which end in a common excretory duct. To this order of glands belong the compound sebaceous glands (§ 139–141, *fig.* 42, *c, d, o, p; fig.* 43, *c, e, f; figs.* 44 and 45, 160 and 161). The Meibomian glands (*fig.* 158), which belong to the sebaceous glands, form links of transition to the compound vesicular glands of the second order; to this place also are to be referred the larger and more complex mucous glands, — the prostate and Cowper's glands.

2. The vesicular compound glands consist, at the limits of their subdivisions, of variously shaped membranous vesicles, — acini, — from the $\frac{1}{80}$th to the $\frac{1}{20}$th of a Paris line in diameter, which, upon the periphery of the glands so constituted, and they are generally of considerable size, appear mutually to compress each other, and to become polyhedral in their outline; the pedicles of these vesicles unite, as they do in the aggregated glands, into tufts; or the pedicles are longer, and combining they form secreting vessels which represent the twigs; these, again, unite and form the branches; and these last

coming together constitute the trunk of the glandular tree. This trunk is generally simple, and forms the excretory duct of the entire gland. The secreted fluid is poured out more or less remotely from the gland that prepares it, either gradually and incessantly, or in larger quantity at particular times. The first generally botryoidal combinations of the elementary vesicles form the glandular granules or acini which are distinguishable by the naked eye; a certain number of these clustered together form the lobules, and these in their turn, connected by cellular substance, constitute the larger lobes, when the structure of the glands happens to be lobular. To glands of this description belong the lachrymal glands, the salivary glands (*figs.* 136 and 137), and pancreas, the lungs, the liver, and the milk or mammary glands.

The fluid secreted by the LACHRYMAL GLANDS is watery and colourless; it consists of from 96 to 99 per cent of water, and of from 1 to 4 per cent of solid matter, made up of a peculiar yellowish extractiform substance, common salt, and traces of soda, phosphate of lime, and phosphate of soda. According to Fourcroy and Vauquelin, human tears contain but one per cent of solid matter, a compound of the yellow extractiform matter not entirely soluble in water, and of common salt. The tears of the domestic mammalia are in all probability little different from those of man. The microscopic elements of tears are a few tessellated epithelial cells from the surfaces of the excretory ducts, and some granules; if the fluid of the lachrymal sac be examined, there will be found mingled with it the campanulate cylinder epithelial cells of the conjunctiva; the products of all the glands that stand in relation to the mucous membranes are always mixed with the detached cells of the glandular epithelia as well as of those with which the ducts are in immediate relation at their orifices.

The SALIVA, examined as it distils from the mouth, contains the large squamiform, granular epithelial cells of the mucous membrane of the mouth, and mucus-granules. Pure saliva is nearly as transparent as water, sometimes watery, sometimes slightly viscid; during the assumption of food it is said to be alkaline, at other times it shews acid reaction. According to the analysis of Mitscherlich and Gmelin it consists of water with about 1½ per cent of solid matters. 1000 parts were found to contain—

Water	985·00
Chloride of potash	1·80
Lactate of potash	1·63
Lactate of soda	0·87
Soda with some mucus	1·64
Phosphate of lime	0·17
Silica	0·15
Sulphate of potash	
Sulpho-cyanate of potash?	
Mucus, about	1·40
Salivary matter,—salivin, ptyalin ...	4·50
Watery extractive	1·50
Alcoholic extractive	1·30
	999·96

The saliva of the horse is transparent, colourless, slightly viscid or susceptible of being drawn into threads, without smell and without taste, which last qualities depend, doubtless, on its saline constituents according essentially with those of the human saliva; it shews alkaline reaction, and, like that of man, deposits flocks when allowed to stand at rest. A drachm of this saliva requires, according to Schulz, a grain of vinegar to saturate it; a drachm of this neutral saliva set aside in a cool place for twenty-four hours required two drops of vinegar to neutralise it again; and the same thing was found to happen again and again until putrefaction commenced. After an interval of a week it was found very acid. The reappearing alkalescence depends, according to Schulz, upon the developement of ammonia; urine is found to comport itself in the same way. According to Lassaigne, the saliva of the horse contains essentially the same principles as that of man, as these are given in the analysis of Gmelin and Mitscherlich. In the saliva of the parotids Gurlt found but 0·787, in that of the submaxillaries, on the contrary, 3·617 per cent of solid matter. As the water of the watery secretions in general increases with the quantity of water taken into and contained in the body, and particularly during damp and cold weather, such discrepancies in the relative amounts of watery and solid constituents ought not to surprise us. In fact, not only do the inorganic salts of the saliva, but its animal constituents—the osmazome and ptyalin—differ according to circumstances, both in the same and in different individuals.

The saliva of the carnivora, and particularly of the dog, has been found more dense, more viscid, and to contain 2·58 per cent of solid matter.

The fluid of the pancreas, as the researches of Leuret and Lassaigne, and of Watrin teach us, is scarcely different from that of the salivary glands of the mouth.

The Bile is the well-known product of the secreting function of the liver, and is contained in man and those animals that have a gall-bladder in this reservoir and in the biliary ducts. The bile of the biliary ducts is yellowish, and more fluid than that of the gall-bladder, which last is more concentrated, of a brownish or greenish yellow colour, a sweetish faint smell, and a decidedly bitter taste. Examined microscopically, the bile is found to contain epithelial cylinders detached from the gall-bladder, mucus-granules, and more rarely fat-globules. The specific gravity of the bile is 1·6352; it shews alkaline reaction, and contains about 10 per cent of solid matters to 90 per cent of water. The solid elements of the bile, according to Frommherz and Gugert, consist of:—

Cholesterine;
Picromel (cholein mixed with cholesterine, according to Berzelius, about 8 per cent);
Colouring matter;
Mucus;
Extractive matter—osmazome as well as a watery extractive of peculiar nature;
(Ptyalin?);
(Casein?);
Cholic, oleic, margaric, carbonic, phosphoric, and sulphuric acids in combination with soda and a smaller quantity of potash; also the phosphate, sulphate (and carbonate) of lime;
Chloride of sodium (Berzelius).

Milk.—Skim-milk from the cow has, according to Berzelius, a specific gravity of 1·0348 at 60° F. The specific gravity of the cream is 1·0244. Skim-milk contains of

Casein rendered impure by the admixture of butter	2·600
Sugar of milk	3·500
Alcoholic extractive—lactic acid and its salts	0·600
Chloride of potassium	0·170
Phosphate of potash	0·025
Phosphate of lime, lime in combination with casein; magnesia, and traces of oxyde of iron	0·230
Water	92·875

Sour milk contains a larger quantity of lactic acid and coagulated casein.

3. The *tubular glands* consist of a congeries of delicate tubes, often of great length, now convoluted, now sinuous, now nearly straight, now branched frequently, now more rarely, which begin on the peripheries of the glands in blind sacs surrounded by a capillary network of vessels. These tubuli are very commonly tortuous, often they are intricately convoluted in their commencements; by and by they run more directly; through their whole course they are surrounded by capillary blood-vessels, lymphatics, and nerves. Frequently they combine and form lobuli or pyramidal subdivisions. After they have united into wider tubuli they combine into several or into a single efferent duct. This structure belongs to those muco-membranous glands which, like the circulating system, begin to be formed in their central and peripheral portions at once, viz.: the kidneys and the testes.

The *urine* is principally secreted in the tubuli of the cortical substance of the kidneys ; by these it is conveyed into the pelvis, from which it finds its way through the ureters into the bladder, whence it is discharged by a voluntary act through the urethra.

This is essentially a watery fluid, not at all viscid, from the palest to the deepest amber colour, of a peculiar aromatic odour, and a saline taste. In specific gravity, it varies from 1·005 to 1·030; its reaction is acid at first, then alkaline after decomposition has commenced. Besides its ordinary or normal constituents, it is apt to contain many substances accidentally taken into the stomach. The analysis of Berzelius makes human healthy urine consist of:—

Water	933·00
Mucus	0·32
Urea	30·10
Uric acid (with urate of soda and ammonia, and colouring matter)	1·00
Lactic acid Lactate of ammonia Alcoholic extractive Watery extractive	17·14
Sulphate of potash	3·71
Sulphate of soda	3·16
Phosphate of soda	2·94
Biphosphate of ammonia	1·65
Phosphate of lime and magnesia	1·00
Muriate of potash Muriate of soda	4·45
Muriate of ammonia	1·50
Fluate of lime Scilica	0·03
	1000·00

The urine of the horse is always turbid; even in the pelvis of the kidney there is a commencing precipitation of minute earthy globules, which destroy its transparency.

The *spermatic* fluid, whose wonderful property is to fecundate the female ovum, and so render it capable of commencing an independent existence, is of thick, almost gelatinous consistency, viscid, stringy, semi-transparent, of a yellowish, greyish or pure white colour, and of a peculiar and often penetrating odour. It has been found to have a specific gravity of 1·0367; and to consist of

Water	90
Spermatine, a peculiar extractive matter	6
Phosphate of lime	3
Soda	1
	100

Examined microscopically, the seminal fluid of all animals is found to contain, mingled with granular molecules and mucus-corpuscles, *peculiar seminal corpuscles*, which at one time appear as aggregation-corpuscles, very similar to mucus-corpuscles and the cells of the yolk (*fig.* 234); at another, as flat granular cells, like pus-corpuscles; farther, peculiar transparent round vesicles, which, besides their fluid contents, inclose granular cells and embryos of spermatozoa,—these may be spoken of as *spermatophori*;* still farther, a multitude of

* *Vide* Wagner, "Fragmente zur Physiologie der Zeugung," and "Elements of Physiology," by Willis, Book I.; also, Valentin, "Ueber die Spermatozoen der Bären in Acta Ac. Nat. Cur." Vol. xix. p. 1. In seminal fluid expressed from the divided substance of the human testicle, Dr. Davy invariably

bodies moving hither and thither amidst the fluid, and which have been long known as the *spermatozoa*, or seminal animalcules; and which, in certain species of animals, particularly in the bear, have even been believed to exhibit something like an internal organisation. The external form and internal organisation of the spermatozoa of the guinea-pig, according to my observations, are still more remarkable; the results of these observations are embodied in the following account:— The body of the spermatozoa of the guinea-pig (*fig.* 231, *a*, *a*) is spoon-shaped, rounded anteriorly and at the edge, more pointed towards the tail, which is from four to five times the length of the body, and is connected with it by means of a slight enlargement (*g*, *h*, *f*). Examined on the abdominal aspect, the oval papilla *d* is perceived in front, the aperture itself being either longer, in the shape of a slit or circular, and, posteriorly, the anal papilla *e*, with the rounded anal orifice. The two most anterior thirds of the body are, for the most part, occupied or made up by transparent globular vesicles (*b*), which have much similarity to the stomachs of the polygastric infusoria; the posterior third includes two rounded very finely granular organs (*c*), which I am inclined to regard as sexual parts. The embryo spermatozoa are

found dense and apparently spherical particles, from ten to fifteen times smaller than the blood-corpuscles. I have also often seen these very minute particles in seminal fluid of the testicle. Dr. Davy conjectures that they may be the ova of the spermatozoa. "Researches, Physiological and Anatomical," vol. i. p. 332.—*G. G.*

evolved in the spermatophori, as in the seminal fluid of some of the lower animals, particularly the cuttle-fish, and are found regularly applied to one another, so as to take up the least possible space (*fig.* 233); in the epididymis they may often be discovered lying together, fifteen and more in number, as they are represented in figure 233.

The compound organisation of the seminal animalcules and their production by no equivocal generation, but in particular sexual organs, and by the means of ova to all appearance, proclaims their affinity to the entozoa. As the seminal fluid that is without these animalcules is incapable of fecundating, their essential importance is abundantly proclaimed.

And here a question might be raised as to whether or not the entozoa which, without the higher organisms they inhabit, could have no existence, ought to be regarded as things necessary to these organisms? But upon this I will not enter; I have, however, thought it right to include figures of one or two of the forms of epizoa and entozoa, very commonly met with in many of the higher mammalia among my illustrations. Figures 229 and 230 are after Bremser; figure 238 is after Raspail.

ORGAN, APPARATUS, SYSTEM.

§ 334. Every part in an animal body which is destined for a more or less especial office is entitled an *organ*, such as a muscle, the eye, the liver, the lung, &c.; several organs which contribute to a common end constitute an *apparatus*;

for example, the larynx, trachea, and lungs, the muscles of respiration, &c.; apparatuses which act together to the accomplishment of a common vital object compose a *physiological system,*— for example, the muscular, the nervous, the circulating, the chylopoetic, and other systems. The *anatomical or formal systems* comprehend parts having the same structure. *Viscus, viscera,* is the term used to designate those organs which are included in the cavities of the body. In the present day the word is restricted to the organs comprised within the thorax, abdomen, and pelvis; the brain is scarcely spoken of now as a viscus. The various systems appertaining to an individual susceptible of an independent existence constitute an individual organism.

LITERATURE OF THE GENERAL ANATOMY.

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CORRECTIONS.

PAGE	
34	Note, line 30, *for* object-glass, *read* object-plate.
35	Note, line 4, *for* found clots of fibrine too compact, *read* found that clots of fibrine were too compact.
36	Note, line 12, after discs, erase the comma, and add G. G. to the note.
58	Note, line 1, *for* its substance, *read* the substance of the gland.
134	Note, line 9, *for* shrewmouse, *read* shrew (*Sorex tetragonurus*).
—	— line 23, *for* vesicles, *read* larger vesicles.
162	Note, *for* ciliæ, *read* cilia.
179	Note ‡, line 7, *for* is, *read* has been.
190	Note, line 6, *for* parenchyme, *read* parenchyma.
200	Note, line 2, *for* were, *read* are.
233	Note, line 7, *after* absent, insert or not visible without the aid of an acid.
270	Note, line 3, erase the words that is.

APPENDIX.

6	Note, line 2, *for* Typhus, *read* Typus.
15	Line 31, *for* Plate 18, *read* Plate 28.
20	Line 10, after nucleoli, insert or nuclei.

EXPLANATION OF PLATES.

59	Line 4, *for* employed, *read* applied, and erase designate.
FIG.	
263	*For* 800, *read* 380.
276	*For* blood-smooth, *read* smooth blood.
280	Line 6, after the word and, insert this appearance.
294	The corpuscles are magnified 800 diameters.

APPENDIX.

OBSERVATIONS ON THE BLOOD-CORPUSCLES OF MAMMIFEROUS ANIMALS.

BY GEORGE GULLIVER, F. R. S.

I. SIZE OF THE CORPUSCLES.

As the blood-corpuscles during health traverse the most minute capillaries in single files, fitted to the internal diameter of the tubes, it is probable that the size of the corpuscles is an exact indication of the capacity of this order of vessels, throughout the whole series of vertebrate animals.

The numerous measurements which I have made during the last five years, of the blood-corpuscles of the mammiferous animals, are here for the first time systematically arranged, carefully revised, and extended by many new observations; and the mean or average sizes are now given, the want of which was felt in my former publications. It will therefore be easy to perceive, as far as the observations go, the size of the corpuscles in relation to the Orders, Families, and Genera of mammals, a most interesting subject, but one that has hitherto attracted very little attention. The measurements are all expressed in fractions of an English inch; and, as shown in the first example, the common sized corpuscles are first set down, then those of small and large size, and lastly the average, deduced from a computation of the whole. The degree of regularity observed in the dimensions of the corpuscles of any one species may be judged of by the number of different measurements which it has been found necessary to note of the common sized discs, better than by attending merely to the extremes, as these may be widely separated with great uniformity of the intermediate sizes, and more closely approximated with very numerous and distinct intermediate gradations. No attempt has been made to record all the measurements that might have been obtained from the corpuscles under examination; but the sizes indicated as common, were such as presented themselves so abundantly as to render it necessary to take them into the account. The regularly formed discs only are noticed in the measurements, as the other corpuscles will be elsewhere mentioned. The observations have been uniformly made by the means formerly explained, * so that, whatever may be the absolute precision of the results, their relative accuracy, which is of the most importance where the chief interest of the subject is derived from comparisons, will probably be deemed worthy of confidence.

The Tables I believe contain a more comprehensive account of the corpuscles in the different species of the class Mammalia than has hitherto been published. The measurements will therefore probably be useful for reference, especially in connection with physiological questions now perpetually arising, and which may be expected to multiply as inquiries in minute anatomy are extended. Indeed the observations were originally instituted principally with the view of ascertaining whether any relation could be shown between the blood-corpuscles and other minute bodies which might be supposed to be derived rather from the red particles of the blood than from the fibrine.

Variation in the size of the corpuscles of a single species of the same age.—I have observed this so distinctly and repeatedly, that it suggested the idea of an organic contrac-

* Lond. and Edin. Phil. Mag. for Jan. and Feb. 1840.

tility of the corpuscles, independently of the remarkable facts presently to be noticed. This variation, indeed, as I have elsewhere remarked, may be very great in disease, and is often sufficiently perplexing in health.* But in the latter state the change of size seems to be confined within certain limits. The corpuscles of the horse, for example, at different times are remarkably variable in magnitude, but never so much so as to render it difficult to distinguish them from those to which they are clearly intermediate in size, as of the rabbit and sheep. Both in the Snowy Owl and Passenger Pigeon, I particularly noticed in blood obtained at different times considerable variations in the long diameter of the corpuscles, although the observations were carefully made on blood drawn from the same bird and vein; yet the variation was never sufficient to alter materially the characteristic figure and size of the corpuscles, which are very singular in the former bird. I have also remarked the same fact in the Quadrumana, particularly in the Lemurs, and in numerous other Mammalia, as well as in various birds and a few reptiles; and Mr. Bowerbank's observations show that the corpuscles of man are liable to a similar change.

It is not uncommon to see the majority of the discs of two remarkably distinct sizes, one about half or two-thirds the magnitude of the other. The larger appear to be the regular corpuscles, and readily run into the characteristic piles, which the smaller seldom do. The two sizes in question seem to be most frequent in blood obtained from dead animals. The smaller variety scarcely ever presents either the swollen edges or the cup-shaped appearance.

The discs often shrink, or become puckered, very quickly after extravasation, particularly in blood which has been effused for a short time into the cellular tissue; and these changes in the corpuscles may sometimes be seen to take place on the object plate of the microscope.

* Some interesting observations on the blood-corpuscles in diseases are given by Dr. Herman Nasse in the "Untersuchungen zur Physiologie und Pathologie." Zweiter Band, Heft. 1. und 2.

Variation in the size of the corpuscles of the same species at different periods of existence.—That the corpuscles are larger at an early period of existence than in the adult, was observed by Hewson * in the common fowl, and in the viper; and M. Prevost † remarked that the corpuscles in the fœtal goat were at first twice the size of those of the mother. In young embryos of Mammalia I have constantly found the corpuscles larger than in the adult, but at a later period of utero-gestation they are sometimes smaller in the fœtus than in the mother: and frequently there is no appreciable difference in the average size, although the variety in the magnitude of the fœtal corpuscles is much greater than in the full grown animal. The former also differ from the corpuscles of the mother in form and in some chemical characters.

Relation between the size of the corpuscles and that of the animal.—Hewson figures the blood-corpuscles as of the same size in the ox, cat, ass, mouse, and bat. Hence it has often been remarked that the size of the corpuscles bears no relation to that of the animal. If, however, we compare the measurements made from a great number of different species of the same order, it will be found that there is a closer connection between the size of the animal and that of its blood-corpuscles than has been generally supposed. ‡ The measurements now given furnish general evidence of this position; and although they also present several exceptions, these will probably fall into order as our knowledge of the subject extends.

Size of the corpuscles in relation to the food of the animal.—It has been stated that in the Carnivora the corpuscles are intermediate in size to those of the omnivorous species and of the strictly vegetable feeders; smaller in the Carnivora, for example, than in man and the Quadrumana, but larger than in the Ruminantia. The same assertion has been extended to the Marsupiata, especially that the red particles of the Perameles, which derives its nourishment

* Experimental Inquiries, part 3. p. 39.

† Annales des Sciences Nat. t. 4.

‡ See Proc. Zool. Soc. Nov. 24, 1840.

from the greatest variety of organized substances, are larger than the particles either of the carnivorous Dasyure or of the herbiverous Kangaroo.

A glance at some of the following measurements will show how little ground there is for this opinion. In one of the ruminants, indeed, the corpuscles are singularly minute, but in another graminivorous animal they are as singularly large: and they are larger in several of the ruminants than in some of the Carnivora. And although among the marsupial animals the corpuscles of the Perameles slightly exceed in size those of the Viverrine Dasyure, yet in the Ursine Dasyure the corpuscles are larger than in either, and just as large, too, as those of Bennett's Kangaroo.

Thickness of the corpuscles.—They are generally slightly thicker in mammals than in man, as appears from the measurements in the Tables. Dr. Hodgkin and Mr. Lister observed this fact in the pig and rabbit.

SIZES OF THE CORPUSCLES IN DIFFERENT MAMMALS.

The corpuscles of the elephant are the largest yet discovered, as first observed by M. Mandl. Those of the Capybara, as noted under the order Rodentia, are next in magnitude. The corpuscles of the goat are stated by Müller * and previous observers to be the smallest known; but from my observations † it appears that the blood-discs of the Napu musk deer, and probably of its congeners, are only about half as large as the discs of the goat.

In the Quadrumana.—The monkeys both of the old and new continents have corpuscles differing but little from those of man, although they appear to be often smaller in the Lemurs. In this family, too, the measurements exhibit greater diversity in the magnitude of the corpuscles of the different species, than among the monkeys.

Cheiroptera.—In the common bat the diameter of the common-sized discs is between $\frac{1}{4570}$th and $\frac{1}{4000}$th of an inch.

* Physiology, by Baly, 2nd ed. part 1. p. 113.

† Med. Chir. Trans. vol. 23. and Dublin Med. Press, Nov. 1839.

Feræ.—In the mole, an insectivorous species, the average size of the corpuscles rather falls short of that generally found in the order, and is considerably smaller than in the plantigrade tribe. The corpuscles of this latter group are larger than those of the other subdivisions of the order, with the exceptions afforded by the genera Canis, Lycaon, Hyæna, Lutra, and Phoca. The corpuscles of the common species of the two latter, and of the dog, appear to be the largest yet known among the Feræ. The most minute corpuscles in the order were also found in the family Carnivora. In the Viverrine and Feline subdivisions the corpuscles appear to be very small as compared with those of the Canine and Phocine tribes; and in the genera Paradoxurus and Herpestes the corpuscles are remarkably so, especially in the Paradoxurus Bondar, * in which they were found to be smaller than any hitherto described in the Feræ. So minute, indeed, are the corpuscles of this animal, that they but slightly exceed those of the goat in size.† Among the Cats, there is a great similarity of the corpuscles; they are only just appreciably larger in the lion, tiger, chetah, and leopard, than in the domestic cat, so that it would require a nice observation to detect any difference. In the Serval and Norway Lynx the corpuscles, obtained after death from the heart, appeared to be fully as large as in any other species of the genus, those of the Ocelot and Persian Lynx presenting the smallest size.‡ In the dog they were uniformly found to be a shade larger than in the fox and some other congenerous species; and both in the striped and spotted hyæna the corpuscles closely resemble

* At the menagerie of the Zoological Society this animal is called Paradoxurus Typhus, but I have lately been assured that it is the P. Bondar of authors ; and it is the same species as that designated P. Typhus in the Phil. Mag. for Jan. 1840. p. 28.

† See Proc. Zool. Soc. Nov. 24, 1840.

‡ The blood from the Persian Lynx and the Ocelot was obtained from living animals. For some observations on the difference in the size of the corpuscles of dead and living animals, see Phil. Mag. for March 1840, page 195 and 197.

those of the genus Canis, and are therefore distinctly larger than in the Viverrine and Feline tribes, with both of which the hyæna has been associated.

It appears then that although there is considerable diversity in the magnitude of the red particles of the order, there is also a well marked relation between these and the different families. Thus the Feræ would stand as follows, if set down in the order of the size of the blood-corpuscles—Seals, Dogs, Bears, Weasels, Cats, Viverras.* The difference in size is generally quite distinct between the corpuscles of the two first and of the two last tribes, the discs of the Weasels forming the connecting link, and being closely allied in magnitude to the corpuscles of the Cats. I am not aware that the affinities of the Basaris have been satisfactorily ascertained. Its blood-corpuscles have pretty nearly the characteristic size of those of the Ursidæ. The corpuscles of the Viverras, as already remarked, are distinctly smaller.

Pachydermata.—As before observed, the corpuscles of the elephant are the largest at present known among mammals. Of the pachydermatous animals, the corpuscles of the rhinoceros are next in size; and those of the Indian Tapir have an average diameter of $\frac{1}{4000}$th of an inch. In the horse they are remarkably variable in size, so that it is common to find the majority of them in the adult animal from $\frac{1}{5300}$th to $\frac{1}{4000}$th of an inch in diameter. Such variations, however, are frequently observed in the corpuscles of animals which we have repeated opportunities of examining.

Ruminantia.—In the ruminants the corpuscles are remarkably interesting. They are generally smaller than in the other orders, and will be found, for the most part, to afford an illustration of the gradation in a natural group of mammals of the size of the corpuscles in relation to that of the animal. In the small ruminants, for instance, as in the goat and sheep, the corpuscles are very small; and in the Napu musk deer, a still smaller animal, the corpuscles are the most minute hitherto described; while on the contrary, in the larger ruminants there is seldom any approach to this

* See Mr. Waterhouse's Observations on the Carnivora, Proc. Zool. Soc. part 7, p. 135.

minuteness of the corpuscles, but they are comparatively large, exceeding in size those of many of the Carnivora. The want of this connection between the size of animals belonging to different orders and that of the blood-discs has already been noticed.

There is often much diversity in the corpuscles of any one species of the order; for the red particles of ruminant animals seem to be particularly liable to modifications both in form and size. It is consequently not always easy to get a good specimen of the regular discs; and the granulated, angular, and jagged particles are very common. In some species of deer the majority of the corpuscles presented the spear-shaped, crescentic, and sigmoid forms, especially when the blood had been kept an hour or two after being abstracted from the animal.

It is in shape only that the oval corpuscles of the Camels resemble those of the lower vertebrate animals. No bird or reptile has yet been found with oval discs so small as those of the mammals in question. The mean of the long and short axes of the Vicugna's corpuscles is only $\frac{1}{4583}$rd of an inch, which is as small as the discs of mammals generally.

Rodentia.—The corpuscles in this order are generally rather large, approaching to those of man and the Quadrumana; and the discs of the Capybara, one of the larger species, appear remarkable for their magnitude. I had, however, only one opportunity of examining the blood of this animal. No instance was found among the rodents of an approach to that minuteness in the average sized corpuscles which is observable in several of the ruminating and carnivorous animals.

Edentata.—In the Weasel-headed Armadillo the corpuscles are as large as those of the Quadrumana.

Marsupiata.—The size of the corpuscles is much the same in this order as in the Rodentia and Edentata. It is singular that there should be a greater difference between the magnitude of the discs of the two species of the carnivorous Dasyure than was observed in any other two species of the order, even when belonging to different families. It will be recollected, however, that there is a remarkable variety in the size of the corpuscles of the placental Carnivora.

II. FORM OF THE CORPUSCLES.

With the few exceptions presently to be noticed, the blood-corpuscles of the Mammalia, if examined in the healthy state and perfectly fresh, present themselves in the form of flattened circular discs, their thickness being about one fourth of their transverse diameter. The edges of the discs are rounded. In the examples given in the Tables, none of the corpuscles appear to be thinner than here mentioned, but some are rather thicker, particularly in one of the Rodentia and in some of the Marsupiata.

The discs often appear flat, without either depression or elevation, but in most cases a slight depression is apparent as they roll over in the field of vision. Hence the opinion formed by Dr. Young, and confirmed by Dr. Hodgkin and Mr. Lister, that the human blood-corpuscles have the form of biconcave discs, coincides with what I have observed in numerous lower Mammalia. But the corpuscles are sometimes rather tumid on the surface—lenticular—and occasionally cup-shaped. They are often swollen at the edges, which, in consequence, project towards the centre, thus producing there triangular, oval, or irregular depressions. The cup-shaped variety is rather frequent in corpuscles which have been mixed a little while with saline solutions ; and it is not uncommon in man, particularly among the particles of purulent or other morbid fluids. The other forms are seldom seen in human blood, although they are very common in the lower Mammalia. Two or three central particles, either oval or circular, giving the idea of air-globules, are sometimes present in the corpuscles. A particle of this kind occasionally occurs singly in the centre of the disc. *

Oval form.—In the Camelidæ the discs have a well-de-

*On this point, see "Observations on the Blood-discs and their Contents" read before the Med. and Chir. Soc. by Mr. Queckett, March 23, 1841. Medical Gazette, vol. 28. p. 74.

fined oval figure. This fact, discovered by M. Mandl in the Dromedary and Paco, led me to examine the blood of the Vicugna and Llama, in both of which the corpuscles were found to present the same oval shape. *

Peculiar oblong forms.—In certain species of deer, as well as in some other mammals, the majority of the corpuscles presented very singular figures, generally oblong, spear-shaped, sigmoid, and polygonal.† These shapes were most abundant an hour or two after the blood had been abstracted from the animals. The fact is remarkable, and will be further noticed in the next Section.

Granulated or mamillated, and angular forms.—These obviously differ both in form and size from the common corpuscles, though also of a red colour and easily acted on by water and acetic acid. As noticed by Hewson, the blood-discs, when about to putrefy, often appear mulberry shaped; but the granulated and angular particles may be found in the blood almost at all times. ‡ I have examined them chiefly in young kittens and puppies. These particles are sometimes very numerous in perfectly recent blood; frequently they are less common, or altogether absent, till the blood has been kept a few hours, when they become numerous, and occasionally they may be seen to increase in the drop of blood on the object-plate of the microscope. They are rather smaller than the common discs, irregular in shape, slightly flattened or nearly globular, with attached spherical granules or vesicles of very minute size. Some of these latter were estimated at from $\frac{1}{30000}$th to $\frac{1}{10000}$th of an inch in diameter. The angular particles, which are generally flattened, are frequently without any granules, though sometimes several of these project from the angles. These irregular blood-discs are represented in fig. 268, after a drawing by Mr. Siddall.

Form in the embryo.—In the young embryo, instead of

* Vid. Med. Chir. Trans. v. 23.

† Proc. Royal Society, Feb. 6, 1840, and Lond. and Edin. Phil. Mag Nov. 1840.

‡ See Lond. and Edin. Phil. Mag., Jan. 1840.

the form of the flat biconcave disc, the corpuscles are lenticular or spherical. Hewson * figured the difference in size and shape between the corpuscles of the embryo and those of the adult, in the domestic fowl and in the viper.

III. CHANGES OF FORM IN THE CORPUSCLES.

The corpuscles have been described by Schultz † as possessing an organic contractility, and even compared by Ebermeyer ‡ to infusory animalcules, while Dr. Barry § observes, that the corpuscles in certain altered states undergo rapid and incessant changes of form, comparable to the writhings of an animal in pain. I have frequently remarked, that the corpuscles are singularly susceptible of alterations, as if from the effect of organic contractility, ‖ especially after extravasation, when the change often takes place very quickly. ¶ In the blood of certain deer the peculiar and remarkable forms mentioned in Sect. 2 were much more abundant than the circular discs—an interesting fact, for if these singular figures result from alterations of the common corpuscles, as there is some reason to suppose, their power of permanently assuming new forms can no longer be doubted; and, as elsewhere remarked, the inquiry is one which may tend to throw some light on the nature of the blood-corpuscles. **

They may often be seen to suffer modifications of shape while circulating in the capillary vessels, becoming suddenly elongated, twisted, or bent, by any narrowing of the

* Exp. Inq. part 3, plate 1, by Magnus Falconer, 1777.

† Ancell's Lectures, Lancet, vol. 1, 1839—1840, p. 147.

‡ Muller's Physiology by Baly, 1837, p. 143.

§ Phil. Trans. part 2, 1840.

‖ Lond. and Edin. Phil. Mag. Jan. 1840.

¶ Ibid. for Feb. 1840.

** Lond. and Edin. Phil. Mag. Nov., 1840, and Proceedings Roy. Soc. Feb. 6, 1840.

channel, and as quickly recovering their original form, after passing the obstacle. Indeed, as M. Mandl remarks, the corpuscles are so very soft and elastic as to be most easily indented.* They may also be frequently seen to undergo similar changes when mixed with some morbid fluids. When a stream of pus-globules, for instance, is running across the object plate, some of the blood-corpuscles accidentally present in the matter, may be seen when they impinge on a grosser particle to alter and resume their form with singular rapidity, running vividly in a serpentine course between the pus-globules, or darting across the field of vision, now appearing deeply concave, spindle-shaped, bent, or indented, and instantaneously returning to their original figure.

The minute molecules of the blood often exhibit very vivid molecular motions.

IV. STRUCTURE OF THE CORPUSCLES.

If blood be diluted with water, it is well known that the corpuscles lose their flat shape and become spherical. They subside, if the mixture be allowed to stand for a few hours, and may be washed by repeated additions of water till completely deprived of their colouring matter. In this state, they may be recognised, with a good instrument and clear light, faintly indeed, perfectly flat and circular, and rather smaller than before the experiment; and the addition of a drop of a strong solution of corrosive sublimate will instantly exhibit these washed corpuscles most distinctly, even when not otherwise visible, and thus they may be preserved for an indefinite time, for demonstration. Acetic acid immediately renders this mixture transparent, completely dissolving the washed corpuscles, unless the acid be rather weak, in which case they may still be faintly

* Anat. Microsc. Liv. 1. p. 13.

brought into view again by the aid of iodine, as in the experiments of Donné and Schultz.

Central Spot.—As this disappears after the removal of the colouring matter by the means just mentioned, it is probable that the spot or depression is caused by the accumulation of this matter at the circumference of the disc. In like manner, the central spot is generally no longer visible when the hematosine begins to dissolve in the serum; and when this takes place from incipient putrefaction, and the edges of the discs appear granulated or notched, the colouring matter may be removed by water; and yet by the aid of corrosive sublimate, the membranous bases of the corpuscles may be seen, for the most part, quite entire, apparently indicating that the jagged appearance was produced merely by a division of the colouring matter.

Nucleus.—In the lower vertebrate animals, nothing can be more distinct than the nucleus of the blood-corpuscles; but it is far otherwise in the Mammalia, as M. Magendie has noticed.* The membranous bases of the discs, as previously described, appear quite flat, scarcely ever exhibiting any aperture or rent through which a nucleus could have escaped; and they may be watched in vain for the appearance of such a body during their solution in acetic acid,—at least all my experiments, which have been very numerous, have given nothing but negative results, although the observations of Professor Müller, made by the aid of acetic acid, enabled him to satisfy himself of the existence of a nucleus in the blood-corpuscles of mammals.† But I am quite convinced that the red particles of mammiferous animals have no nucleus like that found in the lower Vertebrata. "The existence of a nucleus in the blood-corpuscle of man which I was formerly inclined to admit," says that excellent observer R. Wagner, "has lately become with me a matter of doubt." ‡

* Lectures in the Lancet, vol. 1, 1838—39, p. 141, and 858. But the assertion of this eminent Physiologist that the corpuscles of birds are also destitute of nuclei is quite incorrect.

† Physiology by Baly, 2nd ed. part 1. p. 114.

‡ Physiology by Willis, note to Sect. 92.

It appears to me, therefore, that the blood-corpuscles of the Mammalia differ from those of birds, reptiles, and fishes, as completely in structure as in shape. Nor do the oval corpuscles of the Camelidæ afford an exception, for these discs belong both in structure and magnitude to the mammiferous type, exhibiting no nucleus when treated with acids or water, having a size common to the corpuscles of numerous Mammalia, but being distinctly smaller than any diameters hitherto observed in the corpuscles either of birds or reptiles.

V. MICROSCOPIC CORPUSCLES OF THE BLOOD, UNLIKE THE COMMON DISCS.

The irregular particles described in Sect. 2, however peculiar in form, agree with the common discs in colour and chemical properties; but the corpuscles now to be considered differ also in these respects from the red particles.

White Globules.—Nucleated cells or Organic germs of fibrine.*—If a drop of blood be carefully examined with a deep object glass, one or two white globules will generally be seen in each field of vision. The average diameter of these globules is about $\frac{1}{2900}$th of an inch. They are spherical, or nearly so, semitransparent, and for the most part slightly granular on the surface, although sometimes apparently quite smooth. By the aid of acetic acid they generally, like pus-globules, exhibit two or three nuclei, as remarked by M. Donné.

The white globules seem to have no relation either in form or size to the blood discs, for while the latter differ remarkably in some Mammifera, the former seldom vary,

* I use this term in the sense in which it is employed generally by Schwann, and Muller. Henle I think employs the term primary cells. The researches, however, of that excellent observer Valentin tend to show how frequently the so-called nucleus is, in fact, a "nucleolus." See R. Wagner's Physiology, by Dr. Willis, part 1. p. 214.

whatever may be the character of the red particles. In the Napu musk deer, for instance, the white globules are of the same form and size as in man, and so they are in the Camelidæ, differing but slightly even in the lower vertebrate animals. In short, although some care with a good instrument may be requisite to distinguish these globules among the blood discs of man and several other mammals, yet in those just mentioned, as well as in birds, fishes, and reptiles, the white globules are so remarkably different from the red particles as to be instantly apparent. Hence, Spallanzani described the white globules in the salamander; but it does not appear that they were noticed in the blood of mammals till M. Mandl * announced the fact of their existence there three or four years ago.

The nature of the white globules is still a subject for inquiry. M. Mandl considers that they are produced by the coagulation of fibrine, and that this coagulation is necessarily attended by the formation of these globules, which he has detected in the filtered clot of the blood of the frog. He regards the white globules as identical in all respects with those of pus and mucus, and therefore designates all these globules, as well as those of the secretions, *globules fibrineux*. He moreover states that these globules are never found in the circulation, but are formed, and may be seen to augment in number, on the port-object of the microscope ; and Mr. Phillips † adopts this view of the subject. Wagner and Müller ‡ conclude that the white globules are identical with those of lymph ; but the latter physiologist only mentions them in frogs.

The observations on the structure of fibrine in the note at page 28, plate 18, were printed before I was at all acquainted with M. Mandl's ingenious researches; and it was with much inconvenience that a reference to these was subsequently introduced. I mention this again, because it

* Anat. Micros. Liv. 1. p. 16.
† Lect. on Surgery, Medical Gazette, vol. 25, p. 339.
‡ Physiology by Baly, 2nd ed. p. 117.

appears to me that the labours of this physiologist are well worthy of more attention than they have yet received in this country. The corpuscles which I have described as organic germs, M. Mandl would probably consider the same as his fibrinous globules, although the identity between the isolated white globules and the corpuscles represented in Figs. 246—251, seems very questionable. It will be observed that I have figured two kinds of corpuscles in fibrine, viz. cells and their nuclei, the former almost always containing the latter, while the nuclei often appear without the cells. Now M. Mandl in describing pus-globules, which he says are identical with those which he saw in fibrine, rejects the idea of nuclei except as the effect of secondary changes in the globule. I have, however, seldom failed to observe the nuclei very plainly, either naked in the clot of fibrine, (fig. 250,) or contained within a delicate and faint cell, this often so imperfectly formed as to be scarcely discernible, though sometimes very well marked (Figs. 248, 249, and 251.) The nuclei, though occasionally bearing considerable resemblance to those of the pus-globule, are commonly different both in form and size, being generally extremely irregular in shape, rounded or oblong, considerably smaller than the isolated white globules of the blood or of pus, yet larger than the nuclei of these latter. It must, however, be allowed that the method of preparation may have modified the relative appearance of the cells and nuclei, though the question of fact as to the existence of these separate bodies would appear to be decided in the affirmative by the effects of this preparation. In short, independently of other differences, the nuclei and cells are distinct in their chemical characters, the one resisting the operation of some reagents which act energetically on the other.

Hence it is difficult to avoid the conclusion that the corpuscles which I have described as organic germs, are indeed primary or nucleated cells, less definitely formed than these as we commonly see them, but still essentially of the same nature, similar in structure and chemical characters, and probably alike capable of further development if placed in favourable circumstances. The fact of these cytoblasts existing in fibrine which has coagulated quite independently of inflammatory action, would tend to support the view promulgated by an eminent observer, that inflammation is rather hurtful than salutary in the reparation of injuries, and indeed altogether unnecessary for the cure in any case, contrary to the doctrine which had been generally promulgated. *

As stated in the note, page 31—33, the nuclei and their cells are very variable in magnitude. I subjoin some measurements of them (in fractions of an English inch) as observed in the clots from which the figures were taken.

Fig. 247. Boiled fibrine; corpuscles almost uniformly circular.

1—3500
1—3200
———
1—2900

Fig. 249. Cells roundish, and often oval; showing no nuclei when treated with acids.

LENGTH.	BREADTH.
1—1777	1—3555
1—1455	1—3200
———	———
1—1600	1—3369

Fig. 250. Nuclei shown by sulphurous acid. They are round, oblong, and irregular in shape.

LENGTH.	BREADTH.
1—4000	1—12000
1—3000	1—8000
1—2666	1—6400
———	1—4000
1—3129	———
	1—6507

* Dr. Macartney on Inflammation, 4to. Lond. 1838.

Fig. 251. Nuclei much the same size as in fig. 250. Faint envelopes, mostly oval, of the following sizes.

LENGTH.	BREADTH.
1—2000	1—4000
1—1714	1—3200
1—1864	1—3555

The numbers beneath the lines are the estimated averages of the fractions above.

In all my observations a compound microscope was used with achromatic object glasses, either of an eighth or a tenth of an inch focal length, made by two excellent artists, Ross and Powell. These glasses were found necessary to examine the objects satisfactorily, for they became indistinct or invisible with much lower powers. But M. Piorry * has described, in the buffy coat of the blood, greyish granulations, about as big as poppy or hempseeds, which granulations were best seen by transmitted light (contre-jour;) and Mr. Addison has lately given some observations "On colourless Globules of the buffy coat of the Blood,"† which it appears were detected with a common lens. "On dipping the point of the finger on the surface (of the buffy coat) before coagulation had taken place, a clear colourless drop adhered to it, which, when transferred to a piece of glass, and examined by a common lens, against the light, was found to contain an immense multitude of clear colourless globules." Some other observations are mentioned, one of which was made with a Coddington lens, and another with a microscope. That a globular appearance may be seen under the circumstances recorded by Mr. Addison, is not improbable; but as neither the size nor the structure of the globules is mentioned, it is doubtful whether the appearance observed was produced by the granulations of M. Piorry or by the fibrinous globules of M. Mandl.

* Traité de Diagnostic et de Semeiologie, tom. 1, p. 353.
† Medical Gazette, Dec. 1840, No. 681.

It has already been remarked, that Professor Müller considers the isolated white globules of the blood of frogs as lymph-globules; and, as it appears to me, with sufficient reason. M. Mandl, however, dissents from this opinion,* regarding the globules as identical with the fibrinous globules which are formed on the port-object of the microscope, and never seen in the circulating blood.† The identity in batrachian reptiles, between the lymph-globules and the white globules of the blood seems to me pretty certain for two reasons; first, because the latter cannot be distinguished from the globules contained in the subcutaneous lymph of the frog; and secondly, because globules also precisely similar to the white globules of the blood may frequently be observed circulating in the veins of the living frog. These globules are occasionally present in great numbers, moving with singular slowness along the inner surface of the vessel, from which they may often be seen to be detached, and then carried along in the rapid current of blood-discs.

But though the identity in question is thus rendered probable in reptiles, it is not so in mammals, for in this class the white globules of the blood have an average diameter of about $\frac{1}{2800}$th of an inch, which is considerably larger than the lymph-globules, the medium diameter of which is about $\frac{1}{4600}$th of an inch. Besides, the white globules of the blood are quickly dissolved or rendered nearly transparent by acetic acid, so as to expose two or three nuclei,‡ whereas the globules of the juice of the lymphatic glands, treated by the same acid, are simply rendered somewhat smaller and more distinct, seldom exhibiting any nuclei similar to those just mentioned. In fact, I have preserved the lymphatic globules for months in acetic acid with no other change than a slight diminution in their size, and a remarkable increase in the distinctness of their outlines, excepting a few of the

* Anat. Micros. Liv. 1. p. 16, Sect. 5.

† Ibid. Sect. 4.

‡ These are noticed by M. Donné—Mandl. Anat. Micros. Liv. 1. p. 9.

globules which presented the appearance of a single central body quite circular and entire, though occasionally granular, and nearly as large as the globule itself. I have, however, seen in the fluid of the thoracic duct of the horse and of some of the Carnivora, globules precisely similar in size and chemical characters to the white globules of the blood.

Upon the whole it appears, that the white globules of the blood are analogous to the isolated cells of Schwann, * the free nucleoli of Valentin, † and the crude primary cells of Henle. ‡ Scarcely any difference, indeed, either in size or structure, can be detected between the white globules and those of healthy and perfectly recent pus. In inflammatory diseases, especially when attended by suppuration, whitish globules, which I have elsewhere § described as those of pus, may be found in unusual numbers in the blood. The observations of Dr. Davy || are to the same effect, especially as to the greater number of these globules in the blood during suppurative diseases. Mr. Ancell has obtained a similar result;¶ and Henle remarks, that the globules of mucus, which cannot be distinguished from those of pus, are formed wherever the action of the part is increased.

In fine, that the presence of great quantities of these white globules in the blood is referable to disease, I have little doubt. In the horse Mr. Siddall and I have repeatedly seen them in vast numbers, especially when the animal has been suffering from the affection usually termed influenza, and which is prevalent in the spring. In this disease inflammatory fever is very common, with œdema of the legs and other parts, and fibrinous and serous effusions into the pleuræ. Though these white

* Muller's Physiology by Baly, 2nd ed. p. 399.
† Wagner's Physiology, by Willis, part 1, p. 215.
‡ Muller, by Baly, p. 420.
§ Lond. and Edin. Phil. Mag. Sept. 1838.
|| Researches, Phys. and Anat. vol. 2. p, 212.
¶ Lectures in the Lancet, 1839—1840, vol. 2, p. 777.

globules are generally nucleated as before mentioned, yet it frequently happens that acetic acid exerts scarcely any action on them, merely making them rather more distinct, and bringing into view no appearance of nuclei whatever. It is the same, however, with some varieties of pus from abscesses, as noticed in fig. 258. The pus-like globules in the blood of the horse are shown in Mr. Siddall's dawing, fig. 269. Corpuscles formed by an aggregation of small spherules, and quite distinct from the nucleated cells, are occasionally met with in fibrine. This form of corpuscle is mentioned in the note, page 34, and is partly visible near the centre of fig. 246.

White matter.—Besides the globules just described, an abundance of white matter, generally presenting in the form of spherules, may often be observed in blood obtained from mammals after death. These bodies vary in diameter from $\frac{1}{4000}$th to $\frac{1}{1777}$th of an inch. They frequently seem to have a semifluid consistency, especially in the blood of the mesenteric veins, in which the white matter was found most abundantly. It was observed very generally in the blood of the Quadrumana, perhaps in consequence of pathological changes. The animals had died of various diseases, chiefly tubercular phthisis, affecting the spleen and liver quite as commonly as the lungs, and frequently the former organs, when the latter did not contain any appearance of tubercular matter.

Milky serum.—This was often observed, particularly in young animals during digestion; and in two instances both in arterial and venous blood, which was carefully abstracted on one side of the neck from the carotid artery, and on the other side from the jugular vein. The serum was sometimes tinged of a whitish colour, but more frequently a milky film was formed on the surface, the subjacent serum being nearly or quite transparent.

The bulk of this milky matter was composed of spherical particles so exceedingly minute that the highest magnifying power was required to distinguish them with tolerable clearness. The milky matter, indeed, both in its microscopical and chemical characters, was identical with *the molecular base of the chyle,* an account of which will be found further on ; a few larger spherules were also present, as well as a very small number of granules, about $\frac{1}{6000}$th of an inch in diameter. But the milky appearance was entirely owing to the molecular ground just mentioned; and as the animals had been fed specially for the purpose of experiments on the chyle, the characteristic base of this fluid was compared repeatedly with the milky matter of the blood, and no difference could be distinguished between them, either in the form and appearance of the particles or in their chemical properties.

This milky or rather chylous matter, it will be remarked, was found when there was no suspicion whatever of disease; but as I have had no opportunity of observing a similar appearance of the blood in other cases, of course I cannot offer any opinion on the milky serum which appears to have occurred as a pathological condition in several instances noticed by Hewson,* Dr. Babington,† and many other writers.

Through the kindness of Dr. Boyd, however, I have lately had an opportunity of examining a specimen of semiopaque serum, of a dirty white colour, and thickish consistency. It was obtained from a man aged 30, who was bled on account of symptoms of pleurisy. The colour and opacity were perhaps due to a little imperfectly dissolved albumen; the cause of the colour was not disclosed by microscopical examination. When treated with vegetable acids, or with earthy and alkaline salts, no change was produced in the appearance of the serum. On the addition of ether, a pale yellowish matter subsided, which on examination with the microscope appeared to be composed of a congeries of oil-like globules. This matter may possibly be of a peculiar nature. I have seen nothing similar to it, except the delicate matter, which has the same

* Exp. Inq. part 1. 1770. p. 141.
† Cyclop Anat. vol. 1. p. 422—23.

microscopical characters, resulting from the action of ether on chyle. But the morbid serum here noticed, is quite distinct from the milky serum described above.

Minute spherules,—(Fig. 268) very variable in size, but most commonly from $\frac{1}{30000}$th to $\frac{1}{10000}$th of an inch in diameter, were often observed in the blood. They very frequently appeared under the same circumstances as the granulated particles, both generally occurring together as shown in the engraving, the spherules often exhibiting rapid vibratory or molecular motions, and sometimes becoming either attached to, or separated from the granulated particles. Oily globules, very minute also, were occasionally present in the blood, especially in some of the Feræ, as in a leopard that had the entire parenchyma of his kidneys loaded in a remarkable manner with fatty matter. It appears very doubtful whether the minute spherules are the same as the albuminous globules of M. Mandl. *

Corpuscles resembling those of the spleen and suprarenal gland.—In the venous blood of the renal capsule, spherical particles like those of this gland, (Fig. 266.) may often be observed; and in the blood of the splenic vein, corpuscles may sometimes be detected, by the aid of acetic acid, similar to those of the spleen, (Fig. 265.) These facts seem especially deserving of notice, as they may tend to explain the use of the organs in question.

VI. FORMATION AND USE OF THE CORPUSCLES.

Although the formation of the corpuscles of mammals is still a mystery, in the lower vertebrate animals, some observations of much interest have been made on the subject by Wagner,† Valentin,‡ and others, from which it would appear that the blood-corpuscles are, in fact, cyto-

* Anat. Micros. Liv. 1. p. 8.

† Wagner's Physiology by Dr. Willis, part 1 p. 215.

‡ Ibid.

blasts, or free nucleated nuclei. The organic germs or nucleated cells found in clots of fibrine, have been described in the preceding Section and in the note at page 31. Dr. Baly thinks it probable that in the frog the flattened and oval blood-corpuscles are formed from the lymph globules by the flattening and extension of the cell surrounding their nucleus. * White globules, about the same size as those in the blood of man, and probably identical with the proper globules of chyle and lymph, are common in the blood of birds, and particularly abundant after a full meal in the Vultures and other rapacious families. Some of the red discs too, instead of the oval form, are often nearly or quite circular in figure. Hence the blood of these birds would appear especially favourable to observe any changes in the white globules, and it seemed highly probable that these might be transformed into the blood discs in the manner mentioned by Dr. Baly; but although I made many observations with the view of determining this question, nothing but negative results were obtained.

The minute spherules of the blood, as mentioned in the foregoing Section, are often very numerous, particularly in company with the granulated particles. Whether the latter are blood discs in progress of formation, or in the act of separating into young corpuscles, has not yet been determined; nor is it known whether the isolated minute spherules ever become converted into blood discs or any form of cytoblast, though the spherules in question suggest the idea of free nucleoli. Mr. Quecket states that the "parent discs" give out from their interior a number of small globular bodies, † and Dr. Barry ‡ has described a progressive division of the blood-disc into globules, especially in blood obtained soon after coition from the Fallopian tubes of the rabbit. In the venous blood of young kittens I have sometimes seen one of the little spherules become detached from the granulated particle, and pro-

* Translation of Muller's Physiology, part 1. 2nd. ed. p. 156.
† Medical Gazette, Jan. 10, 1840. No. 632.
‡ Phil. Trans. 1840. part 2.

jected into the serum; but some of the free spherules were more frequently observed to attach themselves to the irregular and jagged blood-corpuscles, so as to produce the granulated particles. These phenomena were almost always attended with singularly rapid vibratory or spinning motions of the spherules.

The use of the blood-corpuscles is a subject of much interest, but one about which we have no satisfactory knowledge. Dr. Barry, * however, has recently declared his opinion that the young muscular fibre and the cells of the chorion are formed immediately from the blood discs.

OBSERVATIONS ON THE BLOOD-CORPUSCLES OF BIRDS.

BY GEORGE GULLIVER, F. R. S.

I. SIZE OF THE CORPUSCLES.

The Tables are so full and explicit on this subject, that only a few remarks appear to be necessary. The measurements are given in fractions of an English inch, and set down as noted in the first and second Observations. There is much less variation in the size of the blood-corpuscles of birds than in those of mammals. The differences in the long diameter will of course be more evident than those of the short diameter. It still seems to be a common opinion that the latter is always the same, and that the varieties in the dimensions of the corpuscles are confined

* Loc. cit.

to the former.* This, however, is so far from the truth, that the diversity in their breadth might be shown to have a very near relation to the different diameters of the corpuscles of mammals, of which any one may convince himself by comparing the sizes of the corpuscles of the latter class with the measurements now given of the short diameters of the corpuscles of birds. And as these corpuscles move with their long axis parallel to the sides of the smallest vessels, the short diameter has the same relation to the most minute capillaries of birds, as already mentioned respecting this order of vessels and the blood-discs of mammals.

The length of the corpuscles is for the most part a little less than twice the extent of their breadth, but to this there are some remarkable exceptions, as may be seen by reference to the Tables. The thickness of the corpuscles is about a third, or rather more, of this breadth.

The size of the corpuscles in birds has generally more relation to that of the species than in mammals. No instance in the former class has yet been found of very large corpuscles in the smaller species, and comparatively minute corpuscles in the larger animals, as is the case in several of the latter class. But we still require observations on the blood-discs of the Humming-birds.

Rapaces.—With the exception of the struthious birds, the corpuscles are, on the whole, rather larger in the birds of prey than in the other orders. In the Snowy Owl, the length of the discs is remarkable, the more so, as this is nearly three times as much as their breadth, so that the red particles of this bird are seen at a glance to be very singular.† An excellent observer has recently expressed himself to the following effect,—"En prennant dans les globules sanguins des chameaux, oiseaux, reptiles, et poissons, le petit diamètre pour unité, le grand varie entre $1\frac{1}{2}$ à 2; on en rencontre une exception dans les Crocodiliens,

* Vid. Cyclop. Anat. vol. 1. p. 409.
† Vid. Proc. Zool. Soc. 1840, p. 42.

dont le grand diamètre et 2 à 3 fois plus grand que le petit."*

Omnivoræ.—The corpuscles are smaller than in the preceding order, and the diminution in size generally affects the breadth more in proportion than the length of the discs. They are particularly narrow in the Rose-coloured Pastor, and in the Silky Molothrus. In the Hornbill the corpuscles are very regular in size, but taking the average of their two diameters, as large as any blood-corpuscles to be found among birds, with one or two exceptions.

Insectivoræ.—The corpuscles of the Nightingale are rather longer than the average in relation to their breadth, and those of the Butcher Bird especially so. In fact, the breadth of the latter discs but very slightly exceeds a third of their length. In the other insectivorous birds, the corpuscles are nearly allied to those of the granivorous order.

Granivoræ.—In this order the corpuscles are generally smaller than in the other orders. Many of the smaller species, as the Nutmeg Bird and Lesser Redpole, have very small corpuscles. They are short in relation to their breadth in the common Sparrow and Crossbill, and in some of the other species; and on the contrary the corpuscles of the Snow Bunting are unusually narrow in proportion to their length.

Zygodactili.—The blood of a great number of birds of this order was examined with a view particularly of ascertaining whether the size of the corpuscles varied much in nearly allied genera, and the result appears in the affirmative.

Anisodactyli.—The corpuscles of the Nuthatch and Common Creeper are of small dimensions. There were more circular red discs in the blood of these birds than is

* Mandl, Annales des Sciences Naturelles, seconde serie, tom. 12, p. 289. In the corpuscles, however, of some of the Crocodilidæ, I found that the long diameter was scarcely equal to twice the short diameter. See Proc. Zool. Soc. Nov. 10, 1840.

usual in other species; but I had no opportunity of repeating the observations.

Alcyones.—In two species of this order, the corpuscles were of about the medium size.

Chelidones.—The corpuscles of the Chimney Swallow and of the Martin are slightly shorter than $\frac{1}{2000}$th of an inch.

Columbæ.—We might expect to find an exact resemblance between the elementary parts of such a truly natural family as the *Columbidæ*, and yet the observations show a striking difference between the corpuscles of the Great Crowned Pigeon and those of the Mountain Dove. If the discs of the Passenger Pigeon be compared with those of the birds just mentioned, or of the Russet Pigeon, a still more remarkable difference will be observed, not affecting the size merely, but the form also; for the corpuscles of the Passenger Pigeon are very narrow ellipses, while in the other pigeons this peculiarity of shape is not present.* A similar difference is also to be found among the corpuscles of birds of another very natural group—the *Strigidæ*—as will be seen at once by comparing the dimensions of the red particles of the common Brown Owl with those of the Snowy Owl.

Gallinæ.—In the smaller species of this order the corpuscles are very small, which is not the case, however, in the larger species. The corpuscles of the former are as diminutive as those of the granivorous birds; but in the Peacocks and Curassows, the corpuscles are larger than in the Granivoræ. In the Great Tinamoo the discs appear to exceed in size those of the other gallinaceous birds.

Alectorides.—Like the corpuscles of the rapacious birds, the corpuscles of the Cariama are of large size; and they are rather broader than usual in proportion to their length.

Cursores.—The corpuscles of the Emu are remarkably

* Vid. Proc. Zool. Soc. June 9, 1840.

large, and those of the American Ostrich are but very slightly smaller.

Grallatores.—In this order the corpuscles are of large size, being very nearly allied in this respect to those of the *Rapaces.* The Whimbrel has very narrow discs.

Pinnatipedes.—In the Dab-chick the discs are of a very common size.

Palmipedes.—These birds have generally large corpuscles like those of the rapacious and wading tribes.

II. FORM OF THE CORPUSCLES.

No bird has yet been found with the majority of the corpuscles of any other than the oval form. We have seen, however, that although this ellipse has, for the most part, the proportions which have generally been assigned to it, viz. the long diameter from one and a half to twice the extent of the short diameter; yet, regarding the short diameter as unity, there are some instances in which the long diameter would be $1\frac{1}{4}$ to $1\frac{1}{2}$; and in others 2 to $2\frac{1}{2}$ and $2\frac{1}{2}$ to 3. In other words, the corpuscles may present the figure either of a very broad or of a very narrow ellipse. Those of some of the granivorous birds, as the Common Cross-bill and Java Sparrow, are examples of the former shape; and of the latter, there are instances in several different families, as shown by the corpuscles of the Snowy Owl, Butcher Bird, Passenger Pigeon, and the Snow Bunting.

The discs are generally flat, without either elevation or depression of the surface, though sometimes a slight tumidity is observable in the centre on both sides; and a little indentation may occasionally be seen around this swelling, that is, between the outer part of the nucleus and the circumference of the envelope. The margins of the discs are rounded, and often a good deal compressed; they never appear abrupt like the edge of a cheese.

Circular corpuscles of precisely the same colour and structure as the common corpuscles may sometimes be seen, and every gradation in shape between the round and the regular oval forms may be present.

In the Tables, a few measurements of the nuclei have been given, in order to show that these differ in shape from their envelopes, the former being much longer in proportion to their breadth, than the latter. Some of the nuclei, however, occasionally appear nearly circular, but this is a variation which seldom affects many of them in one field of vision, for the majority almost always have the elongated figure. In fishes the nucleus of the blood-corpuscle is either a very short ellipse or quite circular, thus differing remarkably from the nucleus of the blood-discs of birds.

III. STRUCTURE OF THE CORPUSCLES.

The observations of Hewson, if applied to the corpuscles of birds, are extremely accurate. But in the red particles of mammals no nucleus can be demonstrated like that which may be instantly shown in the corpuscles of any bird, nor do the oval discs of the Camelidæ furnish any exception to this remark. Let any one add a little acetic acid even to the most minute blood-corpuscles of birds, under the microscope, and the field of vision will be instantly filled with the nuclei, which are remarkably distinct and characteristic; but if the same experiment be made with the blood of a mammal, no matter how large and plain the corpuscles may be, a similar result will not follow. It is true that a very few minute spherules may be observed, but these bear no relation whatever in number to the corpuscles which were subjected to the action of the reagent. This, however, does not prove that these corpuscles contain no central matter, but it is surely a fair deduction that the corpuscles of birds differ essentially in this respect from the corpuscles of mammals.

TABLES

OF

MEASUREMENTS OF THE BLOOD-DISCS OF MAMMALIA.

The measurements are all expressed in fractions of an English inch; and the numerator being invariably 1, has been omitted throughout, the denominators only having been printed, except by way of example under the Orang Utan. As shown in this example, the several measurements of the common sized discs are always first set down; the small sized discs are next noticed, then those of large size, and lastly, the average deduced from the whole. A space is left between the common sizes, and those which are here denominated small and large, in preference to extremes, which latter we are seldom certain of having found.

QUADRUMANA.

Catarrhini.

1. Orang Utan. (*Pithecus Satyrus*, Geoff.)

1—3552
1—3429
1—3368 } Common sizes.
1—3309
1—3200

1—4000 Small size.
1—3000 Large size.

———

1—3383 Average.

2. Hoolock Gibbon. (*Hylobates Hoolock*, Harlan.)

3200

4570
2782

———

3368

3. White-whiskered Gibbon. (*Hylobates leucogenys*, Ogilby.)

3428
3200

4570
2900

———

3425

4. A Gibbon. (*Hylobates Rafflesii*, var.)

3600
3555
3429
3200

5333
2900

———

3539

5. Moor Monkey. (*Semnopithecus Maurus*, Cuv. and Geoff.)

3500
3429
3200
5333
2900
——
3515

6. Mona Monkey. (*Cercopithecus Mona*, Schreb.)

3554
3428
5333
2900
4800
2400
——
3468

7. Green Monkey. (*Cercopithecus sabæus*, Desm.)

3200
3555
3600
4000
2666
——
3342

8. Sooty Monkey. (*Cercopithecus fuliginosus*, Geoff.)

3600
3428
3368
3200
5333
3000
——
3530

9. Patas or Red Monkey. (*Cercopithecus ruber*, Geoff.)

3330
4000
3000
——
3395

10. Crown Monkey. (*Cercopithecus pileatus*, Geoff.)

3635
3600
3432
4800
2900
——
3578

11. Vervet Monkey. (*Cercopithecus pygerythrus*, F. Cuv.)

3309
3429
3552
4000
2900
——
3401

12. White-nosed Monkey. (*Cercopithecus Petaurista*, Geoff.)

3555
3428
3200
4570
3000
——
3478

13. Grivet Monkey. (*Cercopithecus griseo-viridis*, Desm.)

4000
3200
3000

5333
2666

——

3429

14. Collared or Mangabey Monkey. (*Cercopithecus Æthiops*, Geoff.)

4000
3200
3555
3000

5333
2666

——

3454

15 Toque Monkey. (*Macacus radiatus*, Desm.)

3200
3600

5333
2900

——

3563

16. Rhesus Monkey. (*Macacus Rhesus*, Desm.)

3200

5333
2666

——

3429

17. Black Ape. (*Macacus niger*, Bennett.)

3554

4572
2965

——

3583

18. Hare-lipped Monkey. (*Macacus cynomolgus*, Desm.)

3429

4800
2666

——

3429

19. Wanderoo Monkey. (*Macacus Silenus*, Desm.)

3600
3552
3270

4570
2666

——

3430

20. Pigtailed Ape. (*Macacus nemestrinus*, Desm.)

3329
3555

4570
2900

——

3493

21. Magot or Barbary Ape. (*Macacus Inuus*, Desm.)

3428
3200

4570
2666

——

3338

22. Black-backed Papio or Indian Ape. (*Macacus melanotus*, Ogilby.)

3432

4570

2666

3389

23. Dog-faced Baboon. (*Cynocephalus Anubis*, F. Cuv.)

4000

3600

3530

3428

3192

3000

5333

2666

3461

24. Drill. (*Cynocephalus leucophæus*, Desm.)

3428

3555

3200

5333

3000

3555

PLATYRRHINI.

25. Chameck Spider Monkey. (*Ateles subpentadactylus*, Geoff.)

3790

3600

3429

4920

2900

3620

26. Black Spider Monkey. (*Ateles ater*, F. Cuv.)

3429

3528

3555

3600

3693

3792

4555

3000

3602

27. Marimonda Spider Monkey. (*Ateles Belzebuth*, Geoff.)

3555

3200

5333

3000

3589

28. Brown Capuchin Monkey. (*Cebus Apella*, Desm.)

3600

3554

3429

3368

4800

2666

3467

29. Weeper or Capuchin Monkey. (*Cebus capucinus*, Geoff.)

3428

3200

4000

4572

2666

3454

30. Squirrel Monkey. (*Callithrix sciureus*, Geoff.)

3790
3693
3600
3552

4800
3200

———

3713

31. Marmozet or Jacchus Monkey. (*Jacchus vulgaris*, Geoff.)

3552
3693

4570
2900

———

3624

32. Marikina or Silky Tamarin. (*Midas Rosalia*, Geoff.)

3693
3429
3332

5333
2666

———

3510

LEMURIDÆ.

33. White fronted Lemur. (*Lemur albifrons*, Geoff.)

4570
4000
3600

6000
2900

———

3976

34. Ring tailed Lemur. (*Lemur Catta*, Linn.)

4000
3840
2644

6000
3000

———

3892

35. Anjouan Lemur. (*Lemur Anjuanensis*, Geoff.)

4365
4268
4000
3500

5333
3200

———

4003

36. Black fronted Lemur. (*Lemur nigrifrons*, Geoff.)

4705
4662
4500
4000

6000
3500

———

4440

37. Slow Lemur. (*Lemur tardigradus*, Linn.)

4000
3552

4570
3000

———

3691

38. Slender Loris. (*Loris gracilis*, Geoff.)
3555
3200
4600
2900
——
3461

CHEIROPTERA.

39. Common Bat. (*Vespertilio murinus.*)
4570
4365
4000
5333
3200
——
4175

INSECTIVORA.

40. Common Mole. (*Talpa Europæa*, Linn.)
5142
4800
4640
4365
6000
4000
——
4747

PLANTIGRADA.

41. Common Badger. (*Meles Vulgaris*, Desm.)
4128
4000
3973
3810
3693
5333
3200
——
3940

42. Polar Bear. (*Ursus maritimus*, Linn.)
3600
3693
3764
3840
4570
5333
3048
——
3870

43. European Brown Bear. (*Ursus Arctos*, Linn.)
3600
3692
3750
3790
4000
4570
3048
——
3732

44. Black Bear. (*Ursus Americanus*, Pallas.)
3600
3693
3790
3840
4570
3000
——
3693

45. Cinnamon Bear. (*Ursus Americanus*, var.)
4000
3693
3790
3840
4800
3000
——
3782

46. Grisly Bear. (*Ursus ferox*, Lewis and Clark.)

3340
3552

4570
3000

3530

47. Sloth Bear. (*Ursus labiatus*, De Blainv.)

4000
3555

4800
3000

3728

48. Raccoon. (*Procyon Lotor*, Cuv.)

4266
4000
3555

5333
3200

3950

49. Brown Coati-Mondi. (*Nasua fusca*, Desm.)

4572
4000
3600
3200

5333
2900

3789

50. Rufous Coati-Mondi. (*Nasua rufa*, Desm.)

4000
3554

5333
3200

3878

51. The Basaris. (*Basaris astuta*, Licht.)

4570
4000
3693

5333
3200

4033

CARNIVORA.

52. White Whiskered Paradoxure. (*Paradoxurus leucomystax*, Gray.)

4500
4365
4000

6000
3200

4236

53. Common or Bondar Paradoxure. (*Paradoxurus Bondar*, Auct.)

5665
6000

7110
4570

5693

54. Two-spotted Paradoxure. (*Paradoxurus binotatus.—Viverra binotata*, Temm.)

4572
4800
5052

6000
3555

——

4660

55. Common Dog. (*Canis familiaris*, Linn.)

4000
3500
3200

4570
2900

——

3542

56. Australasian Dog. (*Canis Dingo*, Blum.)

4000
3555
3200
3000

4570
2666

——

3397

57. Common Fox. (*Canis Vulpes*, Linn.)

4572
4365

4000
3655

——

4117

58. Red American Fox. (*Canis fulvus*, Desm.)

4000
3693

5333
3200

——

3920

59. Black or Silvery Fox. (*Canis argentatus*, Desm.)

4572
4000

5333
2666

——

3888

60. Arctic Fox. (*Canis lagopus*, Linn.)

Same as the preceding.

61. Jackal. (*Canis aureus*, Linn.)

4000
3764
3840 Thickness
4800 14000
3200

——

3860

62. Cape or Black-backed Jackal. (*Canis mesomelas*, Schreb.)

3552
3600
3693
3790

4570
3000

——

3645

63. Common Wolf. (*Canis Lupus*, Linn.)

3554
3635
3692

4570
3000

3625

64. Cape Hunting Dog. (*Lycaon tricolor*, Brookes.)

4000
3693

4570
3200

3801

65. Striped Hyæna. (*Hyæna vulgaris*, Desm.)

4000
3764
3552

4800
3000

3735

66. Spotted Hyæna. (*Hyæna crocuta*, Linn.)

4360
4000
3600
3555

5333
2900

3820

67. Indian Ichneumon. (*Herpestes griseus*, Desm.)

4800
4572
4365

6000
3555

4662

68. An Ichneumon from Java. (*Herpestes Javanicus?*)

5000
4800
4572

6000
4000

4790

69. Smith's Ichneumon (*Herpestes Smithii*, Gray.)

4800
4572
4365
4000

6400
3555

4466

70. African Civet Cat. (*Viverra Civetta*, Linn.)

4500
4433
4120

6000
3200

4274

71. Tigrine Genet. (*Genetta tigrina.—Viverra tigrina,* Schreb.)

4800
5142
5675
6096

6400
4570

——

5365

72. Lion. (*Felis Leo,* Linn.)

4500
4419
4365

6000
3200

——

4322

73. Puma or Silver Lion. (*Felis concolor,* Linn.)

4572
4500
4440

5800
3554

——

4465

74. Tiger. (*Felis Tigris,* Linn.)

4440
4210
4268
4000

5333
3428

——

4206

75 Asiatic Leopard. (*Felis Leopardus,* Linn.)

4800
4570

5333
3200

——

4319

76. Chetah or Hunting Leopard. (*Felis jubata,* Linn.)

4365
4268
4173
4000

5333
3555

——

4220

77. Ocelot (*Felis pardalis,* Linn.)

5333
4800
4057

6400
3200

——

4616

78 Domestic Cat. (*Felis domestica,* Brisson.)

4365
4572

4752
4000

——

4404

79. Persian Lynx. (*Felis Caracal*, Gmel.)

4800
4365

6000
4000

——

4684

80. Norway Lynx. (*Felis cervaria*, Temm.)

4365
4000

5333
3554

——

4220

81. Serval. (*Felis Serval*, Linn.)

4000
4572

6000
3000

——

4129

82. Grison. (*Galictis vittata*, Bell.)

4572
4365
4000

5333
3200

——

4175

83. Zorilla or Cape Weasel, (*Mustela Zorilla*, Desm.)

4572
4500
4000

6000
3000

——

4270

84. Common Ferret. (*Mustela furo*, Linn.)

4800
4500
4000
3693

6000
3000

——

4134

85. Common Otter. (*Lutra vulgaris*, Erxl.)

3600
3200

4800
2910

——

3502

86. Common Seal. *Phoca vitulina*, Linn.)

3554
3200

4000
2666

——

3281

Cetacea.

87. Porpoise. (*Delphinus Phocæna*, Briss.)

4570
4000
3500
3200

6000
3000

———

3829

The blood was obtained from a young Porpoise which had never breathed. It measured 30 inches long, and 14 around the thickest part of the body; it weighed 10 pounds. The corpuscles were similar, both in shape and structure, to the blood-discs of other mammals, viz. circular, and without the nuclei which are peculiar to the blood-corpuscles of the oviparous vertebrata.

Pachydermata.

88. Wild Boar. (*Sus Scrofa*, Linn.)

4266
4365
4000

5333
3555

———

4230

In some blood obtained from a common pig about half grown, the average size of the corpuscles was rather larger than in the Wild Boar. See Phil. Mag. for Jan. 1840, p. 32.

89. Babyroussa. (*Sus Babyroussa.*)

5000
4572
4000

6400
3000

———

4316

90. Collared Peccary. (*Dicotyles torquatus*, F. Cuv.)

4173
4500
4572
4800

6000
3555

———

4490

91. Indian Tapir. (*Tapirus Indicus*, Desm.)

4570
4000
3555

6000
3000

———

4000

92. Asiatic Elephant. (*Elephas Indicus*, Cuv.)

3000
2910
2823
2666
2462

3329
2286

———

2745

93. Rhinoceros. (*Rhinoceros Indicus*, Desm.)

4000
3554
4572
3200
3765

94. Horse. (*Equus Caballus*, Linn.)

	Thickness.
5333	
4800	14000
4572	13330
6000	14663
3555	12000
4706	13422

95. Ass. (*Equus Asinus*, Linn.)

4000
4570
3555
4000

96. Burchell's Zebra. (*Equus Burchellii*, Gray.)

4800
4500
4365
4000
5800
3368
4360

97. Dshikketai, or Wild Ass. (*Equus Hemionus*, Pall.)

4800
4572
4000
5800
3555
4421

RUMINANTIA.

98. Dromedary. (*Camelus Dromedarius*, Linn.)

Long Diameter	Short Diameter
4000	6600
3200	6400
3000	5333
4266	7110
2460	4800
3254	5921

Thickness of the Discs.

16000
20000
12000
15337

99. Vicugna. (*Auchenia Vicugna*, Desm.)

Long Diameter	Short Diameter
4000	7110
3555	6400
3200	6000
5333	8000
2666	5333
3555	6444

100. Guanaco, or Wild Llama. (*Auchenia Glama*, Desm.)

Long Diameter	Short Diameter
4000	6400
3200	6000
3048	8000
4500	5333
2666	6294
3361	

101. Paco. (*Auchenia Paco*, Desm.)

Discs not differing appreciably from those of the Llama.

102. Napu Musc Deer. (*Tragalus Javanicus.* — *Moschus Javanicus*, Pallas.)

13400
12000
16000
9600
———
12325

103. Wapiti Deer. (*Cervus Wapiti*, Mitchell.)

4363
4000
3840
5333
3554
———
4138

104. Sambur Deer. (*Cervus Hippelaphus*, Cuv. Oss.)

4000
3600
4572
3200
———
3777

105. Axis Deer. (*Cervus Axis*, Erxl.)

4924
5333
6000
4365
———
5088

106. Fallow Deer. (*Cervus Dama*, Linn.)

5333
4501
4572
6000
3200
———
4515

107. Moose Deer, or Elk. (*Cervus Alces*, Linn.)

4000
3764
5333
3200
———
3938

108. Barbary Deer. (*Cervus Barbarus*, Bennett.)

4800
5333
4365
———
4800

109. A Deer. (*Cervus macrourus ?*)

5142
5333
6400
4000
———
5074

110. Mexican Deer. (*Cervus Mexicanus*, Licht.)

6000
5000
6400
4000
———
5175

111. Persian Deer. (*Cervus Mahral*, Ogilby.)

5333
5000
4920
4800
6400
4000

——

4978

112. Hog Deer. (*Cervus porcinus*, Zimm.)

6000
5000
6400
4570

——

5391

113. Reeves's Muntjac. (*Cervus Revessii*, Ogilby.)

7200
6400
6000
8000
4920

——

6330

114. Roebuck. (*Cervus Capreolus*, Linn.)

6000
5800
5333
5000
4928
4800
6400
4000

——

5184

115. Giraffe. (*Camelopardalis Giraffa*, Gmel.)

4572
5333
4000

——

4571

116. Indian Antelope. (*Antilope Cervicapra*, Pall.)

6000
5000
4800
6500
4000

——

5108

117. Gazelle Antelope. (*Antilope Dorcas*, Pall.)

5333
4800 Thickness
6000 16000
4000

——

4922

118. Gnu Antelope. (*Antilope Gnu*, Gmel.)

4800
6000
4000

——

4800

119. Sing-Sing Antelope. (*Antilope Sing-Sing*, Ogilby.)

5333
4800
6000
4000

——

5150

120. Philantomb Antelope. (*Antilope Philantomba*, Ogilby.)

6000
5333
4365

6400
4200

5116

121. Nylghau. (*Antilope picta*, Pall.)

4924
4800
4572

6000
4365

4875

122. Cervine or Bubal Antelope. (*Antilope Bubalis*, Pall.)

6856
6400
6000
5333
4572

8000
4000

5600

123. Common Goat. (*Capra Hircus*, Linn.)

6665
6400
6000

8000
5333

6366

124. Cachemire Goat. (*Capra Hircus*, var.)

7200
6400
5858

8000
5333

6430

125. Mouflon. (*Ovis Musmon*. Ham. Smith.)

5331
5142
4924

6400
4000

5045

126. Common Sheep. (*Ovis Aries*, Linn.)

6000
5333
5142
4800

8000
4000

5300

a. A four-horned Sheep from North Africa.

b. A two-horned hairy Sheep from Africa.

c. The hairy Sheep from Demarara.

There was no difference appreciable between the blood-corpuscles of the above varieties of the Sheep. The following measurements were obtained :—

6000
5615
5331
5028

7110
4266

———

5423

127. Aoudad, African Mouflon, or Bearded Sheep. (*Ovis Tragelaphus*, Desm.)

6000
5333

6400
4000

———

5261

128. Common Cow. (*Bos Taurus*, Linn.)

4570
4268
4000

5333
3555

———

4267

a. Brahmin Cow. (*Bos Taurus*, var. Indicus.)

5333
4800
4572

6000
3200

———

4571

129. Bison. (*Bos Bison*, Erxl.)

4266
4000

4572
3554

———

4062

130. Manilla Buffalo. (*Bos Bubalus*, Linn.)

5142
4800
4500

5333
3600

———

4586

Average thickness of the discs.

14000

131. Cape Buffalo. (*Bos Caffer*, Sparman.)

5142
4800

6000
3554

———

4703

RODENTIA.

132. Splendid Flying Squirrel. (*Pteromys nitidus*, Cuv.)

4000
3600

4570
3200

———

3777

133. Lesser American Flying Squirrel. (*Pteromys Volucella*, Cuv.)

3600
4000

4800
3428

———

3892

134. Common Squirrel. (*Sciurus vulgaris*, Linn.)

4570
4500
4370
4000

6000
3555

———

4387

135. Black Squirrel. *Sciurus niger*, Linn?)

3600
3692
3790
3840

6400
3000

———

3841

136. Gray Squirrel. (*Sciurus cinereus*, Gmel.)

4266
4000
3840
3600

6400
3000

———

4000

137. Capistrated Squirrel. (*Sciurus capistratus*, Bosc.)

4000
3790
3693

6400
3000

———

3930

138. Palm Squirrel. (*Sciurus Palmarum*, Briss.)

4400
3692

4800
3000

———

3847

139. Hoary Marmot or Whistler. (*Arctomys ? pruinosus*, Rich.)

3600

4000
3000

———

3484

140. Bandicoot Rat. (*Mus giganteus*, Hardw.)

4000
3600

5333
3200

———

3892

141. Norway or common Rat. (*Mus decumanus*, Linn.)

4266
3554
4000

5000
3200

———

3911

142. Black Rat. (*Mus Rattus*, Linn.)

4000
3692
3448

5333
3000

———

3754

143. Common Mouse. (*Mus Musculus*, Linn.)

4000
3600

5333
3000

———

3814

144. Alexandrian Rat. (*Mus Alexandrinus*, Geoff.)

4172
4000
3810
3764

4800
3200

———

3900

145. Water Rat or Campagnal. (*Arvicola amphibia*, Desm.)

4000
3600

———

3790

146. Bank Mouse or Campagnal. (*Arvicola riparia*, Yarrell.)

4500
4572
4000

5333
3200

———

4199

147. Coendu or Ring-tailed Porcupine. (*Synetheres prehensilis*, F. Cuv.)

3790
3600
3428
3309

5000
2460

———

3444

148. Fournier's Capromys. (*Capromys Fournieri*, Desm.)

3600
3530
3429

4000
3000

———

3483

149. Coypu. (*Myopotamus Coypus*, Desm.)

	Thickness.
3500	
3200	12000
4570	9600
2666	
3355	

150. Common Guinea Pig. (*Cavia Cobaya*, Gmel.)

4000
3764
3448
3368
3200
4570
2900
———
3538

151. Golden Agouti. (*Dasyprocta aurata.*)

3600
5333
3200
———
3857

152. Acouchi. (*Dasyprocta Acouchi*, Ill.)

3600
4000
4572
3200
———
3777

153. Spotted Cavy or Paca. (*Cœlogenys subniger*, F. Cuv.)

3693
3600
3429
3330
4000
3000
———
3481

154. Capybara. (*Hydrochærus Capybara*, Erxl.)

3555
3200
3000
2900
5333
2460
———
3216

155. Common Rabbit. (*Lepus Cuniculus*, Linn.)

4266
4000
3428
3200
5000
2666
———
3607

EDENTATA.

156. Weasel-headed Armadillo. (*Dasypus sexcinctus.—D. Encoubert*, Desm.)

3692
3429
3552
3368
3330
4000
3000
———
3457

MARSUPIATA.

157. Virginian Opossum. (*Didelphis Virginiana*, Temm.)

3600
3530
4570 Thickness.
2900 12000
———
3557

158. Viverrine Dasyure. (*Dasyurus viverrinus*, Geoff.)

4000
4800
3555
———
4056

159. Ursine Dasyure. (*Dasyurus ursinus*, Geoff.)

3600
3428 Thickness.
4365 12000
3000 10000
——— ———
3534 10910

160. Rabbit Perameles. (*Perameles Lagotis*, Reid.)

4572
4000
3428
4800
3200
———
3902

161. Bennett's Kangaroo. (*Macropus Bennettii*, Warterh.)

3600
3432
4000
3200
———
3535

162. A small Kangaroo. (*Halmaturus Derbyanus?* Gray.)

3554
3432 Thickness.
3200 12000
4000 10000
3000 ———
——— 10910
3405

163. Vulpine Phalanger. (*Phalangista vulpina*, Desm.)

3600
3530

5000
2900

———
3617

164 Minute or Pigmy Phalanger. (*Phalangista nana*, Geoff.)

4000
3764
3554

6000
3000

———
3856

165. Squirrel Flying Opossum. (*Petaurista sciureus*, Geoff.)

3600

4800
3000

———
3661

166. Wombat. (*Phascolomys Wombat*, Per. et Lesu.)

3600
3500
3200
3048

5333
2900

———
3456

ADDITIONAL MEASUREMENTS

OF THE

BLOOD CORPUSCLES OF MAMMALIA.

167. Chimpanzee, young male. (*Simia Troglodytes*, Linn.)

3600
3426
3200

4000
3000

3412

168. Noctule Bat. (*Vespertilio noctula*, Schreb.)

4800
4360
4000

6000
3555

4404

169. Pipistrelle Bat. (*Vespertilio Pipistrellus*, Geoff.)

4500
4600
4000

5333
3555

4324

170. Long-eared Bat. (*Plecotus auritus*, Geoff.)

4800
4570

5333
3555

4465

171. Hedge-hog. (*Erinaceus Europæus*, Linn.)

4365
4000

6000
3000

4085

172. Common Shrew. (*Sorex tetragonurus*, Herm.)

5333
4800
4570
4000

6000
3555

4571

173. Common Weasel. (*Mustela vulgaris*, Linn.)

4500
4268
4000
6000
3314
4256

174. Polecat. (*Mustela Putorius*, Linn.)

4570
4000
3600
5333
3500
4167

175. Field Mouse. (*Mus sylvaticus*, Linn.)

4000
3690
5333
3000
3839

BLOOD CORPUSCLES OF THE SIREN.

Siren. (*Siren lacertina*, Linn.)

LENGTH.	BREADTH.
500	888
444	800
400	727
360	
800	1000
333	666
435	800

NUCLEI.

LENGTH.	BREADTH.
1333	2000
1000	1777
1600	4000
888	1500
1142	2007

In the blood of the Siren there were many pale globular or spheroidal corpuscles, apparently growing into perfect blood discs, as represented in the Triton, fig. 294.

Professor R. Wagner, some years since, observed the remarkably large size of the blood corpuscles of the Proteus, and conjectured that those of the Siren were of similar magnitude. (See Proc. Zool. Soc. Nov. 14, 1837.) G. G.

TABLES

OF

MEASUREMENTS OF THE BLOOD-DISCS OF BIRDS.

The measurements are all expressed in fractions of an English inch; and the numerator being invariably 1, has been omitted throughout, the denominators only having been printed, except by way of example under the Bearded Vulture. As shown in this example, the several measurements of the common sized discs are always first set down; the small sized discs are next noted, then those of large size, and lastly, the average deduced from the whole. A space is left between the common sizes, and those which are here denominated small and large, in preference to extremes, which latter we are seldom certain of having found. L. D. denotes the long diameter, and S. D. the short diameter.

Rapaces.

1. Bearded Vulture. (*Gypaëtes barbatus*, Storr.)

LONG DIAMETER.		SHORT DIAMETER.	
1—2000 1—1895	Common sizes.	1—3429	Common size.
1—2286	Small size.	1—4000	Small ditto.
1—1600	Large ditto.	1—3000	Large ditto.
————		————	
1—1913	Average.	1—3425	Average.

2. Turkey Vulture. (*Cathartes Iota*, Bonap.)

L. D.	S. D.
2000	4000
1777	3555
2286	4570
1600	3000
———	———
1880	3691

3. Condor Vulture. (*Sarcorhamphus Gryphus*, Steph.)

L. D.	S. D.
1777	4000
1714	5333
2133	3000
1524	———
———	3892
1761	

4. King Vulture. (*Sarcorhamphus Papa*, Steph.)

L. D.	S. D.
2000	3555
1777	4570
1714	3000
2133	———
1600	3600
———	
1825	

5. Sociable Vulture. (*Vultur auricularis*, Daud.)

L. D.	S. D.
2000	3555
1895	4000
1777	3000
1714	——
2133	3461
1600	
——	
1835	

The nuclei measured exactly the same as those of the White Barn Owl.

6. Griffon, or Fulvous Vulture. (*Vultur fulvus*, Gmel.)

L. D.	S. D.	
1895	3555	
1777	3200	Thick-
1714	4000	ness.
2286	3000	9600
1600	——	
——	3399	
1829		

7. Kolbe's Vulture. (*Vultur Kolbii*, Rüpp.)

L. D.	S. D.
1846	3555
1777	3200
2133	4000
1524	2900
——	——
1794	3337

8. Chinese Vulture. (*Vultur leuconotus*, Gray.)

L. D.	S. D.
1895	3429
1777	4000
1714	3000
2133	——
1600	3425
——	
1806	

9. Brazilian Caracara Eagle. (*Polyborus vulgaris*, Vieill.)

L. D.	S. D.
1895	3600
1777	4000
1714	3200
2286	——
1600	3572
——	
1829	

10. Common Buzzard. (*Buteo vulgaris*, Bechs.)

L. D.	S. D.
2000	3555
1895	4570
1777	3200
1714	——
2286	3691
1600	
——	
1852	

11. Rough-legged Buzzard. (*Buteo Lagopus*, Flem.)

L. D.	S. D.
2000	3555
1895	4570
1777	3200
1714	——
2286	3691
1600	
——	
1852	

12. Golden Eagle. (*Aquila chrysaëtos*, Flem.)

L. D.	S. D.
1777	4000
1714	4570
2286	3200
1600	——
——	3832
1812	

13. Bonelli's Eagle. (*Aquila Bonelli*, Gould.)

L. D.	S. D.
1895	3555
1777	4570
2286	3000
1600	——
——	3598
1866	

14. Wedge-tailed Eagle. (*Aquila fucosa*, Cuv.)

L. D.	S. D.
2000	3555
1895	3200
1777	4570
1714	3000
2286	——
1600	3485
——	
1852	

15. South African Eagle. (*Aquila choka*, Smith.)

L. D.	S. D.
1895	4000
1777	3555
1714	4570
2286	3000
1600	——
——	3691
1830	

16. Short-tailed Eagle. (*Helotarsus typicus*, Smith.)

L. D.	S. D.
2000	3555
1895	4000
1777	3000
2133	——
1714	3461
——	
1891	

17. White-tailed or Cinereous Sea Eagle. (*Haliaëtus albicilla*, Selby.)

L. D.	S. D.
1895	3555
1777	3200
1714	4000
2286	3000
1600	——
——	3390
1829	

18. White-headed Sea Eagle. (*Haliaëtus leucocephalus*, Savig.)

L. D.	S. D.
2000	3555
1777	3200
2286	4000
1684	3000
——	——
1909	3390

19. Chilian Sea Eagle. (*Haliaëtus Aguia*, Benn.)

L. D.	S. D.
1895	4000
1777	3555
1714	3200
2286	4570
1524	3000
——	——
1806	3585

20. Peregrine Falcon. (*Falco Peregrinus*, Linn.)

L. D.	S. D.
2000	4000
1895	4700
1777	3200
2286	——
1714	3862
——	
1916	

21. Kestril Falcon. (*Falco Tinnunculus*, Linn.)

L. D.	S. D.
2000	3555
1714	3200
2460	4570
1600	3000
——	——
1891	3490

22. Hobby Falcon. (*Falco Subbuteo*, Linn.)

L. D.	S. D.
2000	3555
1714	3200
2400	4570
1500	3048
——	——
1827	3507

23. Common Kite. (*Milvus vulgaris*, Flem.)

L. D.	S. D.
2000	4000
1895	3448
1777	4266
2400	3200
1714	——
——	3677
1931	

24. Secretary Vulture. (*Gypogeranus serpentarius*, Ill.)

L. D.	S. D.
1895	3200
1777	4000
1714	2900
1600	——
2133	3301
1391	
——	
1722	

25. Snowy Owl. (*Syrnia Nyctea*, Dum.)

L. D.	S. D.
1600	4000
1500	4570
1455	5333
2000	3000
1333	——
——	4042
1550	

The nuclei of the corpuscles, exposed by the action of acetic acid, were generally $\frac{1}{3200}$th of an inch long, and $\frac{1}{10666}$th broad.

26. Great-eared Eagle Owl. (*Bubo maximus*, Selby.)

L. D.	S. D.
1777	3600
1714	4570
1600	2900
2133	——
1500	3566
——	
1720	

27. Short-eared Owl. (*Otus brachyotos.*)

L. D.	S. D.
1895	4570
1777	4000
1714	5000
1600	3200
2400	——
1455	4076
——	
1763	

28. Virginian Eagle Owl. (*Bubo Virginianus*, Cuv.)

L. D.	S. D.
2000	4570
1895	4000
1777	3555
1714	5333
2286	3200
1524	——
——	4000
1837	

29. Common Brown Owl. (*Syrnium aluco*, Gould.)

L. D.	S. D.
2000	4000
1895	3555
1777	5333
2400	3000
1714	——
——	3801
1930	

30. White, or common Barn Owl. (*Strix flammea*, Linn.)

L. D.	S. D.
2000	4000
1777	4570
2286	3000
1600	——
——	3740
1882	

The nuclei of the corpuscles, exposed by the action of acetic acid, measured generally $\frac{1}{4000}$th of an inch in length, and $\frac{1}{10666}$th in breadth.

OMNIVORÆ.

31. Piping Crow. (*Cracticus hypoleucus*, Gould.)

L. D.	S. D.
2286	4000
2133	4570
2000	3555
2666	——
1714	4000
——	
2116	

32. Pileated Jay. (*Garrulus pileatus*, Temm.)

L. D.	S. D.
2286	4000
2133	5333
2000	3555
2400	——
1600	4167
——	
2041	

33. Raven. (*Corvus corax*, Linn.)

L. D.	S. D.
2133	4000
2000	4570
1895	3555
1777	——
2400	4000
1714	
——	
1961	

34. Jackdaw. (*Corvus monedula*, Linn.)

L. D.	S. D.
2666	4000
2286	5333
2133	3555
2000	——
3000	4167
1777	
——	
2243	

35. Mino Grakle. (*Gracula religiosa*.)

L. D	S. D.
2286	4000
2133	5333
2000	3555
1895	——
2666	4167
1714	
——	
2075	

36. Cornish Chough. (*Fregilus graculus*, Cuv.)

L. D.	S. D.
2286	4570
2133	6000
2000	3555
2460	——
1777	4505
——	
2106	

37. Rose-coloured Pastor. *Pastor roseus*, Brehm.)

L. D.	S. D.
2286	4800
2133	4570
2000	5333
2460	4000
1777	——
——	4630
2106	

38. Chinese Starling. (*Pastor cristatellus*, Temm.)

L. D.	S. D.
2286	4000
2133	4800
2000	3555
2666	——
1777	4050
——	
2133	

39. Paradise Grakle. (*Pastor tristis*, Temm.)

L. D.	S. D.
2133	4000
2000	5333
1895	3555
2460	——
1600	4167
——	
1993	

40. Common Starling. (*Sturnus vulgaris*, Linn.)

L. D.	S. D.
2286	4000
2133	4800
2000	3555
2666	——
1895	4050
——	
2165	

41. Silky Molothrus. (*Molothrus sericeus*, Wagl.)

L. D.	S. D.
2286	4800
2133	4570
2000	6000
2666	3555
1777	——
——	4567
2133	

42. Hornbill, from the Island of Sincapore. (*Buceros Rhinoceros?* Shaw.)

L. D.	S. D.
1777	3200
1714	3000
1600	4570
2286	2666
1333	——
——	3230
1690	

INSECTIVORÆ.

43. Common Wren. (*Troglodytes Europæus*, Cuv.)

L. D.	S. D.
2400	4570
2286	4000
2900	5333
2000	3200
——	——
2359	4133

44. Golden-crested Wren. (*Regulus cristatus*, Flem.)

L. D.	S. D.
2400	4570
2286	4000
3000	5333
1777	3200
——	——
2284	4133

45. Nightingale. (*Philomela luscinia*, Sw.)

L. D.	S. D.
2286	4800
2000	4570
1777	5333
1714	4000
2460	——
1600	4630
——	
1927	

46. Black-cap Warbler. (*Curruca atricapilla*, Bechs.)

L. D.	S. D.
2400	4570
2286	4000
2900	5333
2000	3200
——	——
2359	4133

47. Common Robin. (*Erythaca rubecula*, Sw.)

L. D.	S. D.
2460	4570
2400	4000
2286	5333
2133	3200
2900	——
1895	4133
——	
2305	

48. Hedge Sparrow. (*Accentor modularis*, Cuv.)

L. D.	S. D.
2460	4000
2400	4570
2286	3555
2666	——
2000	4000
——	
2342	

49. Missel Thrush. (*Turdus viscivorus*, Linn.)

L. D.	S. D.
2403	4000
2286	4570
2133	3555
2666	——
1895	4000
——	
2247	

50. Song Thrush. (*Turdus musicus*, Linn.)

L. D.	S. D.
2400	4570
2286	4000
2133	5333
2000	3200
2666	——
1895	4133
——	
2203	

51. American Robin. (*Turdus migratorius*, Linn.)

L. D.	S. D.
2460	4570
2400	4000
2286	5333
2133	3200
3000	——
2000	4133
——	
2348	

52. Wamew Bird, or Crying Thrush. (*Turdus canorus*, Lath.)

L. D.	S. D.
2400	4000
2286	4800
2133	3200
2900	——
2000	3892
——	
2305	

53. Common Blackbird. (*Merula vulgaris*, Ray.)

L. D.	S. D.
2286	4000
2133	4570
2000	5333
2400	3555
1777	——
——	4256
2097	

54. Mocking Bird. (*Orpheus polyglottis*, Sw.)

L. D.	S. D.
2400	3555
2286	5333
2000	3000
2666	——
1895	3732
——	
2223	

55. Spotted fly-catcher, (*Musicapa grisola*, Linn.)

L. D.	S. D.
2400	4570
2286	4000
2000	5333
2666	3200
1777	——
——	4133
2179	

56. Greater Butcher bird, or Shrike. (*Lanius excubitor*, Linn.)

L. D.	S. D.
2286	6000
2133	5142
2000	5800
1777	6400
1714	4000
2900	——
1600	5325
——	
1989	

Granivoræ.

57. Rice bird. (*Dolichonyx oryzivorus*, Sw.)

L. D.	S. D.
2460	4000
2400	5333
3000	3555
2000	——
——	4167
2416	

58. Rufous-necked Weaver bird. (*Ploceus textor*, Sw.)

L. D.	S. D.
2286	4570
2133	5333
2666	4000
1895	——
——	4575
2213	

59. Dominican Grosbeak, or Red-headed Cardinal. (*Cardinalis Dominicana*, Linn.)

L. D.	S. D.
2460	3555
2286	3790
2133	4570
2000	3000
1895	——
2666	3643
1777	
——	
2140	

60. Red-crested Grosbeak, or Red-crested Cardinal. (*Cardinalis cucullata*, Daud.)

L. D.	S. D.

Same as in C. Dominicana.

61. Cut-throat Sparrow. (*Amadina fasciata*, Sw.)

L. D.	S. D.
2000	4570
2400	5333
1714	3555
——	——
2001	4364

62. Nutmeg bird. (*Amadina punctularia.*)

L. D.	S. D.
2460	4570
2400	4800
2286	6000
2900	4000
1895	——
——	4740
2342	

63. Common Sparrow. (*Pyrgita domestica*, Cuv.)

L. D.	S. D.
2400	4000
2286	4570
2133	3000
2666	——
2000	3732
——	
2273	

64. African Sparrow. (*Pyrgita simplex.*)

L. D.	S. D.
2400	4000
2286	5333
2133	3200
2666	——
2000	4000
——	
2273	

65. Chaffinch. (*Fringilla Cœlebs*, Linn.)

L. D.	S. D.
2286	4570
2133	4000
2900	5333
1895	3200
——	——
2253	4133

66. Amaduvade. (*Fringilla amandava*, Linn.)

L. D.	S. D.
2286	4800
2133	6000
2666	4000
2000	——
——	4800
2243	

67. Lesser Red pole. (*Linaria minor*, Ray.)

L. D.	S. D.
2666	4800
2400	5000
2286	6000
2900	4000
2000	——
——	4848
2416	

68. Yellow Bunting. (*Emberiza citrinella*, Linn.)

L. D.	S. D.
2460	4000
2400	5333
2286	3555
2133	——
2900	4167
2000	
——	
2337	

69. Crested Bunting, or Black crested Cardinal. (*Emberiza cristata*, Sw.)

L. D.	S. D.
2460	4000
2400	5333
2286	3555
2133	——
2900	4167
1895	
——	
2310	

70. Snow Bunting. (*Plectrophanes nivalis*, Meyer.)

L. D.	S. D.
2286	4800
2133	4570
2000	6000
2666	4000
1777	——
——	4740
2133	

71. Common Crossbill. (*Loxia curvirostra*, Linn.)

L. D.	S. D.
2460	4000
2400	4570
2900	3555
1895	——
——	4000
2365	

72. Java Sparrow. (*Loxia Javensis*, Shaw.)

L. D.	S. D.
2400	4000
2286	3555
2900	4800
2000	3200
——	——
2359	3803

73. Waxbill. (*Loxia Astrild*, Linn.)

L. D.	S. D.
2400	4800
2286	4570
2133	6000
2666	4000
2000	——
——	4740
2273	

74. Malacca Grosbeak. (*Loxia Malacca*, Linn.)

L. D.	S. D.
2400	4000
2286	5333
2900	3555
2000	——
——	4167
2359	

ZYGODACTYLI.

75. Buffon's Touraco. (*Corythaix Buffonii*, Jard. and Selb.)

L. D.	S. D.
2000	4000
1777	3555
2400	4570
1600	3200
——	——
1902	3764

76. Roseate Cockatoo. (*Plyctolophus Eos*, Vig. et Horsf.)

L. D.	S. D.
2133	4000
2000	3555
1895	4800
1777	3000
2666	——
1684	3728
——	
1981	

77. Lesser Sulphur-crested Cockatoo. (*Plyctolophus sulphureus*, Vieill.)

L. D.	S. D.
2400	3555
2286	3200
2133	4000
2000	3000
2666	——
1895	3399
——	
2203	

78. Rose-crested Cockatoo. (*Plyctolophus rosaceus*, Vieill.)

L. D.	S. D.
2000	3555
1895	4570
1777	2900
1714	——
2400	3547
1500	
——	
1842	

Nuclei $\frac{1}{4000}$th of an inch long and $\frac{1}{12000}$th broad.

79. Great Sulphur-crested Cockatoo. (*Plyctolophus galeritus*, Kuhl.)

L. D.	S. D.
2000	3555
1777	4570
2286	3000
1600	——
——	3600
1880	

80. Lesser White-crested Cockatoo. (*Plyctolophus Philippinorum*, Vieill.)

L. D.	S. D.
2133	4000
2000	4570
1895	4800
1777	3200
2400	——
1600	4041
——	
1974	

81. Red and Yellow Maccaw (*Macrocercus Aracanga*, Selb.)

L. D.	S. D.
2133	4570
2000	4000
1895	4800
1777	3200
1714	——
2400	4041
1600	
——	
1902	

82. Illiger's Maccaw. (*Macrocercus Illigeri.*)

L. D.	S. D.
2000	4570
1895	5333
1777	3500
2400	——
1684	4335
——	
1924	

83. Blue and Yellow Maccaw. (*Macrocercus Ararauna*, Vieill.)

L. D.	S. D.
2133	4570
2000	4000
1895	5333
1777	3200
2460	——
1684	4128
——	
1961	

84. Red and Blue Maccaw. (*Macrocercus Macao*, Vieill.)

L. D.	S. D.
2133	4572
2000	4800
1895	6000
1777	4000
1714	——
2400	4762
1600	
——	
1902	

85. Brazilian Green Maccaw. (*Macrocercus severus*, Vieill.)

L. D.	S. D.
2286	4000
2133	3555
2000	4800
2666	3200
1895	——
——	3801
2165	

86. Pennantian Ground Parrakeet. (*Platycercus Pennantii*, Vig. et Horsf.)

L. D.	S. D.
2286	4000
2133	4570
2000	3400
2460	——
1777	3931
——	
2106	

87. Macquarrie Ground Parrakeet. (*Platycercus Pacificus*, Vig.)

L. D.	S. D.
2286	4365
2133	4800
2000	3555
2666	——
1714	4174
——	
2118	

88. Nonpareil or Rose Hill Ground Parrakeet. (*Platycercus eximius*, Vig. et Horsf.)

L. D.	S. D.
2286	4000
2133	4800
2000	3200
2900	——
1895	3892
——	
2193	

89. Yellow-bellied Ground Parrakeet. (*Platycercus flaviventris*, Vig.)

L. D.	S. D.
2286	4000
2133	4800
2000	3200
2666	——
1714	3892
——	
2118	

90. Vasa Ground Parrakeet. *Platycercus Vasa*, Vig.)

L. D.	S. D.
2286	4000
2133	4800
2000	3200
1895	——
2400	3892
1714	
——	
2045	

91. King's Ground Parrakeet. (*Platycercus scapulatus*, Vig. et Horsf.)

L. D.	S. D.
2133	4570
2000	4000
1895	5333
2400	3000
1684	——
——	4042
2000	

92. Lesser Vasa Ground Parrakeet. (*Platycercus niger*, Vig.)

L. D.	S. D.
2286	4000
2133	4800
2000	3200
2666	——
1777	3892
——	
2133	

93. Crested Ground Parrakeet. (*Nymphicus Novæ Hollandiæ*, Wagl.)

L. D.	S. D.
2286	4000
2133	4570
2000	4800
2900	3555
1777	——
——	4174
2160	

94. Slight billed Parakeet Maccaw. (*Psittacara leptorhyncha*, Vig.)

L. D.	S. D.
2286	4000
2133	4570
2000	3400
1895	——
2666	3931
1684	
——	
2067	

95. Grey-breasted Parrakeet or Quaker bird. (*Psittacara murina.—Psittacus murinus*, Gmel.)

L. D.	S. D.
2286	4000
2133	5000
2000	3400
2666	——
1777	4031
——	
2133	

96. Patagonian Parrakeet Maccaw. (*Psittacara Patachonica*, Vig.)

L. D.	S. D.
2286	4000
2133	4570
2000	3500
2666	——
1714	3977
——	
2115	

97. All-green Parrakeet. (*Psittacara viridissima*, Vig.)

L. D.	S. D.
2133	4000
2000	4570
1895	5000
2666	3500
1684	——
——	4190
2029	

98. Solstitial Parrakeet Maccaw, or Yellow Parrakeet Maccaw. (*Psittacara solstitialis*, Vig.)

L. D.	S. D.
2286	4000
2133	4570
2000	3555
2666	——
1777	4000
——	
2133	

99. Yellow-winged Parrakeet. (*Psittacara virescens*, Vig.)

L. D.	S. D.
2286	4000
2133	5333
2000	3555
2400	——
1777	4175
——	
2097	

100. Blue-faced Parrakeet. (*Trichoglossus capistratus*, Vig. et Horsf.)

L. D.	S. D.
2400	4000
2286	4800
2133	3200
2000	——
2666	3892
1895	
——	
2203	

101. Alexandrine Parrakeet. (*Palæornis Alexandri*, Vig.)

L. D.	S. D.
2286	4000
2133	4800
2000	3200
2666	——
1714	3892
——	
2115	

102. Ring-necked Parrakeet. (*Palæornis torquatus*, Vig.)

L. D.	S. D.
2400	4000
2286	4800
2133	3200
2000	——
2666	3892
1777	
——	
2174	

103. Blossom-headed, or Rose-headed Parrakeet. (*Palæornis Bengalensis*, Wagl.)

L. D.	S. D.
2400	4000
2286	5333
2133	3200
2666	——
2000	4000
——	
2278	

104. Purple-capped Lory. (*Lorius domicellus*, Selb.)

L. D.	S. D.
2286	4570
2133	4000
2000	5333
2500	3200
1714	——
——	4133
2093	

105. Ceram Lory. (*Lorius Ceramensis*, Briss.)

L. D.	S. D.
2286	4000
2133	5333
2000	3200
2666	——
1714	4000
——	
2115	

106. Great Crimson, or Amboyna Lory. (*Lorius Amboinensis*, Briss.)

L. D.	S. D.
2286	4000
2133	4570
2000	5333
1895	3200
2460	——
1684	4133
——	
2045	

107. Indian Lory. (*Lorius coccineus.*)

L. D.	S. D.
2000	4000
2133	4570
2286	3555
2666	——
1895	4000
——	
2165	

108. Chinese Lory. (*Lorius Sinensis.—Psittacus Sinensis*, Gmel.)

L. D.	S. D.
2400	3555
2286	4570
2133	3200
2000	——
1895	3692
2666	
1714	
——	
2115	

109. Great-billed ground Parrakeet. (*Tanygnathus macrorhynchus*, Wagl.)

L. D.	S. D.
2286	4000
2133	5000
2000	3000
2460	——
1777	3829
——	
2106	

110. Gray, or Ash-coloured Parrot. (*Psittacus erythacus*, Linn.)

L. D.	S. D.
2000	4000
1895	5333
1777	3200
2400	——
1600	4000
——	
1898	

111. White-fronted Parrot. (*Psittacus albifrons*, Lath.)

L. D.	S. D.
2000	3555
1895	4000
1777	4570
2460	3000
1684	——
——	3692
1931	

112. Imperial Parrot. (*Psittacus Augustus*, Vig.)

L. D.	S. D.
2286	3555
2133	4570
2000	3000
1895	——
2666	3600
1714	
——	
2085	

113. Lesser Green Parrot. (*Psittacus Americanus*, Linn.)

L. D.	S. D.
2286	3555
2133	4570
2000	3000
2666	——
1714	3600
——	
2115	

114. Golden-crowned Parrot. (*Psittacus regulus.*)

L. D.	S. D.
2133	3555
2000	4000
1895	4570
2666	3200
1714	——
——	3764
2037	

115. Dufresne's Parrot. (*Psittacus Dufresnii*, Lath.)

L. D.	S. D.
2400	3270
2286	4000
2133	3000
2900	——
1895	3374
——	
2278	

116. Yellow-headed Amazonian Parrot. (*Psittacus Amazonicus*, Briss.)

L. D.	S. D.
1895	4000
1777	4570
1714	3200
2286	——
1500	3832
——	
1800	

117. White-headed Parrot. (*Psittacus leucocephalus*, Auct.)

L. D.	S. D.
2286	4000
2213	3555
2000	4800
1895	3000
2400	——
1684	3727
——	
2050	

118. Bay-headed Parrot. (*Psittacus badiceps*, Vig.)

L. D.	S. D.
2286	3764
2133	3600
2000	4000
2900	3200
1777	——
——	3617
2165	

119. Blue-headed Parrot. (*Psittacus menstruus*, Linn.)

L. D.	S. D.
2286	3600
2133	4570
2000	3200
2666	——
1714	3708
——	
2115	

120. Black-headed Parrot. (*Psittacus melanocephalus*, Gmel.)

L. D.	S. D.
2133	4000
2000	4800
1895	3200
2460	——
1684	3892
——	
2005	

121. Mitred Parrot. (*Psittacus mitratus*, Temm.)

L. D.	S. D.
2133	4000
2000	5333
1895	3000
2666	——
1684	3892
——	
2029	

122. Grey-headed Parrakeet. (*Psittacula cana*, Wagl.)

L. D.	S. D.
2000	4000
2133	5333
2666	3555
1777	——
——	4174
2101	

123. Red-headed Guinea Parrakeet. (*Psittacula pullaria*, Wagl.)

L. D.	S. D.
2286	4000
2133	5333
2000	3555
2400	——
1777	4174
——	
2097	

124. Lesser spotted Woodpecker. (*Picus minor*, Linn.)

L. D.	S. D.
2286	4000
2000	5333
2900	3000
1777	——
——	3892
2170	

ANISODACTYLI.

125. Nuthatch. (*Sitta Europæa*, Linn.)

L. D.	S. D.
2400	4570
2286	4000
2133	5333
2666	3200
1777	——
——	4128
2213	

Average size of the nuclei, when exposed by acetic acid, $\frac{1}{11000}$th of an inch broad, and $\frac{1}{4572}$nd long.

126. Common Creeper. (*Certhia familiaris*, Linn.)

L. D.	S. D.
2666	4000
2400	5333
2133	3200
2900	——
1777	4000
——	
2305	

Alcyones.

127. Laughing Kingfisher. (*Dacelo gigantea*, Leach.)

L. D.	S. D.
2268	3555
2000	4000
2666	3200
1714	——
——	3555
2110	

128. Kingfisher. (*Alcedo Ispida*, Linn.)

L. D.	S. D.
2400	3790
2286	3555
2133	4570
2000	3000
2666	——
1600	3693
——	
2124	

Chelidones.

129. Chimney Swallow. (*Hirundo rustica*, Linn.)

L. D.	S. D.
2286	4000
2133	5333
2000	3200
2666	——
1777	4000
——	
2133	

130. Martin. (*Hirundo urbica*, Linn.)

L. D.	S. D.
2286	4000
2133	
2666	
1777	
——	
2170	

Columbæ.

131. Ring Dove or Cushat. (*Columba Palumbus*, Linn.)

L. D.	S. D.
2000	3555
1895	4790
2400	3000
1714	——
——	3643
1973	

132. Collared Barbary or Turtle Dove. (*Columba risoria*, Auct.)

L. D.	S. D.
2286	3555
2000	3200
2666	4800
1777	3000
——	——
2133	3523

133. Turtle Dove. (*Columba Turtur*, Linn.)

L. D.	S. D.
2133	3428
2000	3200
1895	4000
2400	3000
1714	——
——	3369
2005	

134. Surat Turtle or Necklace Dove. (*Columba tigrina*, Temm.)

L. D.	S. D.
2286	3600
2133	4570
2000	3000
1895	——
2666	3615
1777	
——	
2088	

135. Russet Pigeon. (*Columba rufina.*)

L. D.	S. D.
2400	3428
2286	4000
2666	3000
2000	——
——	3429
2314	

136. Bronze-winged Pigeon. (*Columba chalcoptera*, Temm.)

L. D.	S. D.
2460	4266
2286	4000
2133	4570
2000	3555
2666	——
1895	4062
——	
2208	

137. Nicobar ground Pigeon. *Columba Nicobarica*, Gmel.)

L. D.	S. D.
2286	4000
2133	3555
2000	4570
2666	3000
1777	——
——	3692
2133	

138. Triangular-spotted Dove. (*Columba Guinea*, Linn.)

L. D.	S. D.
2286	4000
2133	4570
2000	3200
2666	——
1895	3839
——	
2165	

139. Coro or Gray Dove. (*Columba Corensis*, Gmel.)

L. D.	S. D.
2286	3555
2133	4790
2000	3000
2900	——
1895	3643
——	
2193	

140. Mountain Dove. (*Columba aurita*, Linn.)

L. D.	S. D.
2460	3448
2400	4000
2286	3200
3000	——
2133	3519
——	
2422	

141. Zenaida Dove. (*Columba Zenaida*, Bonap.)

L. D.	S. D.
2400	3600
2286	4000
2133	3200
2000	——
2666	3571
1895	
——	
2203	

142. Passenger Pigeon. (*Columba migratoria*, Linn.)

L. D.	S. D.
2133	4800
2000	4570
1895	5333
1777	4000
1714	——
2666	4626
1542	
——	
1909	

143. Great crowned Pigeon. (*Columba coronata*, Auct.—*Lophyrus*, Vieill.)

L. D.	S. D.
2133	3555
2000	3200
1875	4570
1777	3000
2400	——
1600	3491
——	
1954	

Gallinæ.

144. White crested Guan. (*Penelope leucolophos*, Merrem.)

L. D.	S. D.
2000	4000
1777	3555
2400	3429
1600	4570
——	2900
1902	——
	3607

145. Crested Guan. (*Penelope cristata*, Gmel.)

L. D. S. D.

Same as in *Penelope leucolophos.*

146. Globose Curassaw. (*Crax globicera*, Linn.)

L. D.	S. D.
2133	3428
2000	3200
1895	4570
2286	2900
1714	——
——	3425
1985	

147. Red Curassaw. (*Crax rubra*, Linn.)

L. D.	S. D.
2133	4000
2000	3555
1895	3200
2400	5333
1684	3000
——	——
1993	3664

148. Yarrell's Curassaw. (*Crax Yarrellii*, Benn.)

L. D.	S. D.
2213	3555
2000	3200
1895	4570
1777	2900
2666	——
1714	3456
——	
2000	

149. Razor-billed Curassaw. (*Ourax mitu*, Cuv.)

L. D.	S. D.
2133	3555
2000	3200
1895	4570
2400	3000
1714	——
——	3490
2005	

150. Common Peacock. (*Pavo cristatus*, Linn.)

L. D.	S. D.
2000	4000
1895	3200
1777	4570
1714	3000
2133	——
1600	3589
——	
1835	

151. Japan Peacock. (*Pavo muticus*, Linn.)

L. D. S. D.

Same as in the common Peacock.

152. Java Peacock. (*Pavo Javanicus*, Horsf.)

L. D.	S. D.
2000	3555
1895	3200
1777	4570
2286	3000
1600	——
——	3491
1884	

153. Golden Pheasant. (*Phasianus pictus*, Linn.)

L. D.	S. D.
2286	3600
2133	4570
2666	3000
1895	——
——	3615
2213	

154. Silver or pencilled Pheasant. (*Phasianus nycthemerus*, Auct.)

L. D.	S. D.
1895	3555
1777	4000
2286	3000
1684	——
——	3470
1887	

155. Barred-tailed Pheasant. (*Phasianus superbus*, Lath.)

L. D.	S. D.
2133	3555
2000	3200
1895	5333
1777	3000
2400	——
1684	3587
——	
2128	

156. Common Turkey. (*Meleagris gallapavo*, Linn.)

L. D.	S. D.
2286	3555
2133	4570
2000	3000
1895	——
2400	3598
1714	
——	
2045	

157. Rendall's Guinea Fowl. (*Numida Rendallii*, Ogilby.)

L. D.	S. D.
2286	4800
2133	4570
2000	6000
1895	3200
2460	——
1714	4415
——	
2054	

158. European Francolin. (*Francolinus vulgaris*, Gould.)

L. D.	S. D.
2400	4000
2286	4570
1777	5333
2666	3000
1714	——
——	4041
2106	

159. Long-billed Partridge. (*Perdix longirostris*, Lath.)

L. D.	S. D.
2286	4000
2000	3555
1895	5333
2666	3000
1684	——
——	3801
2054	

160. Argoondah Quail. (*Coturnix Argoondah*, Sykes.)

L. D.	S. D.
2460	3555
2400	4000
2286	3000
2666	——
2000	3470
——	
2347	

161. American Quail. (*Ortyx Virginianus*, Bonap.)

L. D.	S. D.
2400	4000
2286	4570
2133	3555
2666	——
1777	4000
——	
2213	

162. Welcome Quail. (*Ortyx neoxenus*, Vig.)

L. D.	S. D.
2460	4000
2400	4570
2286	3200
2133	——
2666	3836
2000	
——	
2305	

163. Capercailzie. (*Tetrao urogallus*, Linn.)

L. D.	S. D.
2400	4000
2286	4570
2133	3200
2666	——
1895	3836
——	
2248	

164. Black Grouse. (*Tetrao tetrix*, Linn.)

L. D.	S. D.
2460	4000
2400	3555
2286	4800
2900	3000
2000	——
——	3728
2376	

165. Great Tinamoo. (*Tinamus Braziliensis*, Lath.)

L. D.	S. D.
1895	3428
1777	3200
1714	4570
1684	2666
2133	——
1455	3338
——	
1752	

Alectorides.

166. Cariama. (*Dicholophus cristatus*, Ill.)

L. D.	S. D.
2000	3200
1895	4266
1777	2900
2286	——
1600	3364
——	
1884	

Cursores.

167. Emu. (*Dromaius Novæ Hollandiæ*, Vieill.)

L. D.	S. D.
1777	3000
1714	4000
1684	2460
1600	——
2000	3031
1455	
——	
1690	

Nuclei.

L. D.	S. D.
4000	10666
3000	8000
3429	9133

168. Rhea or American Ostrich. (*Rhea Americana*, Briss.)

L. D.	S. D.
2000	3428
1895	4000
1777	2666
2400	3273
1600	
1898	

Thickness of the discs,

9140

GRALLATORES.

169. Stone Curlew. (*Œdicnemus crepitans*, Temm.)

L. D.	S. D.
2400	4000
2286	4570
2133	3555
2000	4000
2666	
1714	
2157	

170. Oyster Catcher. (*Hæmatopus Ostralegus*, Linn.)

L. D.	S. D.
2133	4000
2000	5333
1895	3200
1777	4000
2286	
1684	
1942	

171. Numidian Crane or Demoiselle. (*Anthropoides Virgo*, Vieill.)

L. D.	S. D.
2000	4000
1895	4572
1777	3000
2666	3740
1455	
1884	

Thickness of the discs.

12000
10666

11230

172. Stanley Crane. (*Anthropoides Stanleyanus*, Vig.)

L. D.	S. D.
2000	3692
1895	3552
1777	3200
2286	4570
1684	3000
1909	3529

173. Balearic crowned Crane. Balearica pavonina, Vig.)

L. D.	S. D.
2133	4000
2000	3600
1777	4572
1600	3200
2460	——
1500	3777
——	
1859	

Thickness of the discs.

12000
8000
——
9597

Nuclei.

L. D.	S. D.
4000	9140
	12000
	8000
	——
	9750

174. Cape crowned Crane. (*Balerica Regulorum*, Lichs.)

L. D.	S. D.
1895	3500
1714	3200
2400	4570
1600	3000
——	——
1858	3478

175. Common Heron. (*Ardea cinerea*, Linn.)

L. D.	S. D.
2000	3555
1895	3200
2286	4570
1600	3000
——	——
1913	3491

176. Night Heron. (*Ardea Nycticorax*, Linn.)

L. D.	S. D.
1895	3555
1777	3429
2133	4570
1455	3000
——	——
1780	3555

177. White Spoonbill. (*Platalea leucorodia*, Linn.)

L. D.	S. D.
1895	3555
1777	4570
2666	3000
1455	——
——	3600
1859	

178. White Stork. (*Ciconia alba*, Ray.)

L. D.	S. D.
1777	3600
1714	3429
2286	4570
1455	2666
——	——
1755	3439

179. Black Stork. (*Ciconia nigra*, Ray.)

L. D.	S. D.
1895	3329
1777	3555
1714	4570
2133	2666
1600	——
——	3403
1806	

180. Argala Stork. (*Ciconia Argala*, Vig.)

L. D.	S. D.
1777	4000
1600	3200
2666	5333
1333	2666
——	——
1728	3555

181. African Gigantic Crane. (*Ciconia Marabou*, Vig.)

L. D.	S. D.
2000	3555
1777	3200
1714	5333
2400	2666
1600	——
——	3460
1859	

182. Whimbrel. (*Numenius Phœopus*, Lath.)

L. D.	S. D.
2000	4800
1777	4570
1714	5333
2286	3555
1600	——
——	4465
1846	

183. Black tailed Godwit. (*Limosa melanura*, Leisler.)

L. D.	S. D.
2000	4000
1895	3555
2400	4570
1714	3200
——	——
1973	3764

184. Land Rail from New Holland. (*Rallus Phillipinensis*, Lath.)

L. D.	S. D.
2286	4000
2133	4570
2000	3200
2400	——
1777	3839
——	
2097	

185. Water Hen or Moor Hen. (*Gallinula chloropus*, Linn.)

L. D.	S. D.
2133	4000
2000	4570
2400	3200
1777	——
——	3839
2055	

PINNATIPEDES.

186. Little Grebe, Black chin Grebe, or Dab Chick. (*Podiceps minor*, Lath.)

L. D.	S. D.
2000	3200
2133	4000
2460	2666
1600	——
——	3200
2001	

PALMIPEDES.

187. Spur-winged Goose. (*Plectropterus Gambensis*, Steph.)

L. D.	S. D.
1895	4000
1777	3429
2133	4570
1714	3200
——	——
1866	3728

188. Egyptian Goose. (*Chenalopex Ægyptiaca*, Eyton.)

L. D.	S. D.
2000	4000
1895	4570
1777	3200
1714	——
2400	3839
1600	
——	
1866	

189. Cereopsis Goose. (*Cereopsis Novæ Hollandiæ*, Lath.)

L. D.	S. D.
1895	4000
1777	3555
1714	4570
1600	3000
2000	——
1455	3692
——	
1722	

190. Sandwich Island Goose. (*Bernicla Sandvicensis*, Vig.)

L. D. S. D.

Same as in the Egyptian Goose.

191. Magellanic Goose. (*Bernica Magellanica.—Anas Magellanicus*, Gmel.)

L. D. S. D.

Same as in the Egyptian Goose.

192. Black Swan. (*Cygnus atratus*, Shaw.)

L. D.	S. D.
1895	3600
1777	4500
1714	3200
2133	——
1600	3692
——	
1806	

193. White-masked Whistling Duck. (*Dendrocygna viduata*, Eyton.)

L. D.	S. D.
1777	3555
1714	4000
2133	3200
1600	——
——	3555
1789	

194. Red-billed Whistling Duck. (*Dendrocygna autumnalis*, Eyton.)

L. D.	S. D.
2000	4000
1895	3555
1777	4570
2286	3200
1714	——
——	3764
1916	

195. Black-billed Whistling Duck. (*Dendrocygna arborea*, Ayton.)

L. D.	S. D.
1000	4000
1895	3428
1777	4570
2400	3200
1714	——
——	3724
1931	

196. Summer Duck. (*Dendronessa sponsa*, Sw. and Rich.)

L. D.	S. D.
2286	4000
2000	5000
1895	3500
1777	——
2666	4079
1684	
——	
2001	

197. Sheldrake. (*Tadorna vulpanser*, Flem.)

L. D.	S. D.
2000	4000
1895	4570
1777	3200
2400	——
1684	3839
——	
1925	

198. Widgeon. (*Mareca Penelope*, Selb.)

L. D.	S. D.
2000	4570
1895	5333
1777	3600
1714	——
2460	4385
1600	
——	
1873	

199. Common Teal. (*Querquedula crecca*, Steph.)

L. D.	S. D.
2286	5333
2000	4570
1895	4266
2666	6000
1714	3555
2062	4592

200. Pintail Duck. (*Querquedula acuta*, Selby.)

L. D.	S. D.
2133	4000
2000	4570
1895	3200
1940	
2400	3839
1714	
1993	

201. Garganey Teal. (*Querquedula circia*, Steph.)

L. D.	S. D.
2286	4000
2133	4570
2000	3200
2460	
1714	3839
2088	

202. Black-headed Gull. (*Larus ridibundus*, Linn.)

L. D.	S. D.
2286	4000
2133	4570
2000	3555
2400	
1777	4000
2097	

203. White Pelican. (*Pelecanus Onocrotalus*, Linn.)

L. D.	S. D.
1895	3555
1777	3200
1714	4570
2286	2666
1600	
	3369
1830	

204. Cormorant. (*Phalacrocorax carbo*, Steph.)

L. D.	S. D.
2133	4000
2000	3555
1895	4570
2400	3200
1714	
	3765
2005	

OBSERVATIONS ON TUBERCLE.

The term Tubercle is here confined to the well-known morbid product which occurs in various organs, and which constitutes in particular the essence of that common and fatal disease—pulmonary consumption. This appears to be the sense in which the term is generally employed in this country; but it will be perceived that the plastic exudations (§ 315) which form the greater part of Mr. Gerber's varieties of tubercle, are merely different states of the coagulated lymph or fibrinous exudations, the matter of morbid adhesions or false membranes, of English writers. For example, in what does his hyaline tubercle differ from that product of inflammation frequently mentioned by French and English authors as gelatiniform lymph? And how can the fibrinous exudation or the false membrane which I have had depicted (Figs. 243 and 272) be said to differ from the descriptions which Mr. Gerber has given of tubercle (§ 315.) But the difference between tubercle and plastic exudations is of the utmost importance, and has been insisted on in an especial manner by English pathologists. "Tuberculous matter," says Dr. Carswell, "is a pale yellow, or yellowish grey, unorganized substance. * * * The most important fact connected with tuberculous matter is, that, either from the nature of its constituent parts, the mode in which they are combined, or the circumstances in which they are placed, they are not susceptible of organization, and, consequently, give rise to a morbid compound, capable of undergoing no change that is not induced in it by external agents." (Cyclop. Prac. Med. vol. 4, pp. 253 and 256.) To this description the unorganized or granular tubercles only of Mr. Gerber can be referred (§ 314.)

His fibrinous tubercles, which he says "present important varieties, including every conceivable difference between the substance of any plastic exudation and that of a complete internal cicatrix," would seem to pertain, as already remarked, to those organizable or organized productions which are not regarded as tubercle in this country. The drawings, which will convey the leading results of my observations,* were executed long since; and Plate 29 was finished and struck off, and the explanations of the figures printed, before I was acquainted with Mr. Gerber's views concerning tubercle, or even knew that this term occurred in his work.

It most frequently happens that tubercle exhibits no regular structure, so that the nicest examination can detect nothing more than a granular matter, minute spherules, and shapeless flakes or fragments, as represented in Fig. 271; this is especially the case in caseous tubercle, whether occurring in the lungs or elsewhere. Sometimes the fragments, though still shapeless, are more distinct, yet unlike cells or their nuclei; and many of the minute spherules may be attached to some of the fragments (Fig. 270.) In smaller tubercles corpuscles are often seen, having much the character of cells or their nuclei; the envelopes are either absent or indistinctly blended with a minutely granular base (Figs. 252—254.) It is only in minute and recently formed tubercles that perfect cells exist; Fig. 255 was made from a tubercle not bigger than a millet-seed. Cytoblasts and cells, however, may sometimes be found at the periphery of crude tuberculous matter; and corpuscles which are probably effete cytoblasts are often present in softened tubercle. In tubercles of the most recent formation, I have occasionally seen vesicles like those represented in Fig. 273, and an aggregation of these sometimes forms a pretty large tubercle. These vesicles appear to me to be much more common in the lower animals, particularly in the quadrumana, than in man; and they are

* Vid. Dublin Med. Press, April 7, 1841.

most easily examined in transparent parts, as the omentum. But it is especially necessary to avoid confounding fat vesicles with the products of disease. The Figure just mentioned much resembles one given by Dr. Baron, (" Illustrations of the Inquiry respecting Tuberculous Diseases." Lond. 1822. Plate 1.) although it does not appear that this ingenious inquirer has depicted microscopic vesicles in the plate now referred to; but I have at present no opportunity of consulting his original work.

It would seem, then, that the following parts most commonly compose the minute texture of tubercle. They may either occur separately, or be mixed together in various proportions. The granular matter is seldom or never absent.

1. *Granular matter.*—This is composed of infinitely minute particles, as seen in the matrix containing the corpuscles and cells in Figs. 252—255, and of minute spherules (Fig. 271) remarkably variable in magnitude, generally from $\frac{1}{30000}$th to $\frac{1}{8000}$th of an inch in diameter. Granular matter is the most prevalent ingredient of tubercle, almost always mixed with the other constituents, and frequently forming nearly the entire mass of caseous tubercle.

2. *Corpuscles.*—These are generally more or less globular or oval, (Figs. 252—254) but often either very irregular in form or shapeless. (Fig. 270.) They usually vary from $\frac{1}{6000}$th to $\frac{1}{2000}$th of an inch in diameter. They are probably imperfect, degenerating, or blighted cells and nuclei. The corpuscles may be seen in crude or mature tuberculous matter; also commonly in the smallest caseous tubercles, especially of the serous membranes. The granular matter preponderates as the tuberculous mass increases.

3. *Cells.*—The most common size of these is from $\frac{1}{2600}$th to $\frac{1}{1140}$th of an inch in diameter. They may be frequently recognized in greyish miliary tubercles, either of the lungs or serous membranes; but as the tubercles increase in magnitude, the well marked and complete cells (Fig. 255) disappear, probably degenerating into the corpuscles and granular matter above mentioned.

From the preceding observations it appears highly probable that tubercle, like the most highly organized tissues, has its origin in cells; but generally mixed at a very early period with granular matter. Tubercle, however, seems to differ essentially from the matter of plastic exudations, inasmuch as the cells of the latter not only grow into a higher organization, but increase also in number towards the centre; in other words, plastic matter has an inherent power of multiplying and evolving organic germs. But tubercle has no such power; for it would appear that its primitive cells can only retrograde and degenerate, since they are wholly destitute from the beginning of the plastic force.

G. G.

OBSERVATIONS ON THE CHYLE,

AND

ON THE FLUID OF THE THYMUS AND OF THE LYMPHATIC GLANDS.

My inquiries concerning these fluids have been prosecuted at intervals for several years. Some of the results, of which a short and necessarily imperfect notice was given in the Dublin Medical Press, Jan. 1, 1840, will now be related more particularly, yet as briefly as possible. In the experiments on the chyle, dogs and cats were chiefly used; and the contents of the lacteal system in other animals were examined as opportunities occurred. A large quantity of chyle was once procured from the different parts of its containing channels in the lynx, and a smaller portion from a man who was found dead in his bed, some hours after eating a supper of bread and butter with cheese and salad. The human thymous and lymphatic juice, as well as that of various lower mammals, was repeatedly made the subject of observation.

I. Chyle.

The anatomy of the Chyle is by no means so simple as has been generally supposed. The particles which it contains may be thus enumerated:—1. Extremely minute particles, either of uniform size or varying within very narrow limits, and constituting the peculiar matrix which will here be called *the molecular base* of the chyle; 2.

Globules ; 3. Blood corpuscles ; 4. Oily globules ; 5. Minute spherules, very unequal in size, snd similar in appearance to those of some other animal matters.

Molecular Base.—(Figs. 274—278.) From whatever part of its containing channels, the rich, milky, opaque chyle may be procured, its bulk or principal mass is a peculiar white matter, having a greyish appearance by transmitted light, and composed of particles so minute that they may be said to be near the uttermost extent of vision as aided by the best instruments. These particles form the molecular base of the chyle ; and this base, as it appears to me, is unlike any other animal matter. In poorer chyle, which is semi-transparent or opaline, the molecular base is more diluted, so that its particles float thinly or separately in the transparent fluid, and often exhibit the vivid motions common to the most minute molecules of various substances. The particles of the base appear to be spherical ; and the majority of them, as estimated by the plan in Fig. 274, are probably between $\frac{1}{36000}$th and $\frac{1}{24000}$th of an inch in diameter.

The earthy and alkaline salts produce no change in the particles of the molecular base ; nor are they affected by the caustic alkalies, judging from trials with the common solutions of potass and ammonia, nor by the acetic, muriatic, citric, and tartaric acids; but the former acid usually clusters the particles into masses, as if from coagulation of the fluid of the chyle. When treated with æther, the molecular base instantly disappears, and that completely, not a particle of it remaining; the chyle becomes transparent, excepting a small quantity of a light brown or whitish matter ; this forms a nearly pellucid substratum, sinking towards the bottom of the test-tube, but never entirely reaching it. The chyle globules may be distinguished, scarcely changed, in this solution in æther of the molecular base. In some trials which were made with the milk of the cow and giraffe, æther did not produce similar effects, but the milk retained its opacity, quickly sinking to the bottom, after the mixture was agitated; and the same result was observed when the thymous fluid was treated with æther. The whitish substratum above mentioned seems to be almost entirely composed of delicate spherules (Fig. 282) much resembling those of oil in figure and inequality of size, but, as seen by transmitted light, paler and more translucent. These spherules, however, are by no means confined to the matter just noticed, for they may be observed after mixing æther with a variety of animal matters, as the brain, cruor, mucus, &c. When the chyle has coagulated, the clot and the fluid part are equally white. Treated with æther, the latter becomes transparent, and the former nearly so; yet the globules may be still seen entire in the substance of the clot.

The bulk or matrix of the chyle, therefore, appears to be a peculiar white matter, composed of particles remarkable for their minuteness, equal size, ready solubility in æther, and unchangeableness when subjected to the action of numerous other reagents which quickly affect the chyle globules; and those properties, with the singularly uniform ground which it presents in the microscopic field of vision, are the distinguishing characteristics of the molecular base.

As formerly noticed (Appendix, p. 21—23, and Dublin Med. Press, April, 1841,) the molecular base of the chyle is sometimes found in the blood, abstracted during digestion. The blood of younglings most frequently exhibits this chylous matter; but I have twice seen it in the blood of adults, taken from the animals at the instant of death, and allowed to stand a few hours. One was a cat nearly full grown, the other a dog not quite twelve months old. Both were well fed after having been kept thirty hours without food; the former was killed four hours after eating bread and milk, the latter six hours after a meal of cow's paunch, bones and potatoes. The milky blood observed by Schlemm and Meyer in sucking kittens and puppies was concluded to be owing to the absorption of the fat of the milk by the lacteals (Traité de Physiologie, par C. F. Burdach, traduit de l'Allemand par A. J. L. Jourdan, tome ix. p. 358—9.) The molecular base of the chyle, however, has neither the microscopical nor chemical characters of milk. As both the arterial and venous blood may contain the molecular base in a free state (Appendix, p. 21:) it results that the whole of this matter is not always immediately assimilated even after it has passed through the lungs.

Globules of the chyle.—(Figs. 275, 277, 278, 281, and 283.) In the human subject, and in the cat, dog, and lynx, the globules are much alike in size, varying from $\frac{1}{7110}$th to $\frac{1}{2600}$th of an inch in diameter, although the majority are about $\frac{1}{4600}$th. The magnitude of the globules hardly differs from whatever part of the lacteal system they may have been obtained.

The globules are usually minutely granulated on the surface, seldom exhibiting any nuclei, even when treated with acetic acid; but something like two or three central molecules may now and then be seen, especially when water is added; and a dilute solution of muriatic acid generally renders the surface of the globules smoother, occasionally with intumescence, but for the most part with slight diminution of size, and often with the appearance of a single round nucleus (Fig. 283.) In the largest globules, from the thoracic duct particularly, the action of acetic acid sometimes discloses three or four central particles, similar to those which may be frequently seen by the aid of this acid in the white globules of the blood. These latter are generally larger than the average-sized chyle and lymph globules: but though the white globules of the blood, as well as the larger chyle globules, frequently exhibit the central molecules, yet it as often happens that these cannot be seen by any method of preparation (See Appendix, p. 19—20.)

Strong muriatic acid destroys the chyle globules, reducing them to particles of extreme minuteness, apparently from solution of the medium by which the latter are united. The globules are not soluble in acetic acid, but they are slightly reduced in size by it, probably from solution of their most superficial part (See note p. 83—84.) The neutral alkaline and earthy salts act slowly on the globules, but certainly, for they are always soon made irregular at their margins, less distinct, and ultimately quite invisible: but this latter effect may not be observed in less than three or four days, though it generally takes place in the course of an hour or two.

As to the relative number of the globules in different parts of the lacteal system the following notes were made, using an achromatic object-glass of one-tenth of an inch focal length adapted to the second eye-piece. In chyle of the peripheral lacteals, either of the intestine or mesentery, from three to twelve globules were most commonly seen in one field of vision, but they were occasionally absent, and sometimes not to be discovered till after several shiftings of the stage. In the chyle of the mesenteric glands, whether obtained from a prick in one of their lacteals, or from the cut surface of the gland, the globules were always remarkably abundant; nearly as numerous when the lacteal system was turgid, as in the rich thymous fluid. In chyle of the central lacteals from ten to thirty globules were generally found in one field of vision; that is to say, they were more numerous than in the chyle of the peripheral lacteals, but considerably less so than in that of the mesenteric glands (see note, p. 57.) In chyle of the receptaculum and thoracic duct the number of globules appeared to be the same as in the central lacteals; and the globules of the latter, when taken from the vessels just as they emerge from the gland, were often more plentiful than in the chyle of the thoracic duct.

The chyle from the receptaculum and thoracic duct coagulates very quickly, often almost instantaneously; and when the clot becomes pretty firm, the globules will be found aggregated together and imprisoned therein, (Fig. 281,) so that very few or none of them remain in the liquid. It is remarkable, however, that in the clot the globules often appear less regular in shape, and increased in number, so as to lead to the suspicion that these are not all identical with the common chyle globules.

Blood Corpuscles.—(Fig. 276.) In carnivorous animals it often happens that no blood-corpuscles can be found in the chyle; yet I have repeatedly seen them when the utmost caution was used to prevent any accidental mixture of blood with the chyle. Whether they must be regarded as foreign to the lymph and chyle or as belonging to one only or to both of these fluids, is a subject of much interest. Our distinguished countryman Hewson observed completely formed blood particles in the efferent lymphatic vessels, particularly in the lymphatics of the spleen ; (Experimental Inquiries, part 3, Edited by Magnus Falconar, Lond. 1777, pp. 122, 112, and 135,) and I have sometimes seen red discs, generally rather smaller than those of the blood, in the coloured fluid of the same vessels of the ox and horse. In chyle from the thoracic duct of the latter animal, Mr. Gerber has depicted many discs in form and colour like those of the blood; and Mr. Lane attributes the rosy tint of the chyle of this animal to the presence of blood particles. (See note p. 59.) My own observations are to the same effect: in one instance blood corpuscles from the heart were carefully compared with those from the thoracic duct, when the former were found to have an average diameter of $\frac{1}{4700}$th of an inch, while the latter were only $\frac{1}{5800}$th. In the blood of the heart the corpuscles had their usual form; but in the chyle, although they were of a reddish colour, the majority were either irregularly indented at the edges or granulated, not more than a fourth of the entire number presenting the ordinary disc-like figure. At their circumference several of them had the little spherules so regularly arranged, (see fig. 268,) as to render it probable that the outer coloured part of the blood corpuscle was thus being formed. To ascertain whether any of these peculiarities might not have been caused by the action of the chyle on the blood corpuscles, some of the latter from the heart were mixed with the same animal's chyle, and observed to undergo no change. The blood discs in the chyle of the dog (Fig. 276) were nearly a third smaller than those from the same animal's heart.

Monro, after opening the bodies of living animals, and some time thereafter the upper end of the thoracic duct, found many red particles mixed with the contents of the duct; but he thought the appearance might be due to the absorption of blood corpuscles which had been extravasated in consequence of inflammation. (On the Structure and Physiology of Fishes, fol. Edin. 1785, p. 37.) In short, Schmidt, Schultz, Gurlt, and Valentin, have all seen blood corpuscles in the chyle; and Ernest Burdach, Krimer, and Arnold, state that they have observed the globules of the chyle assume a red colour, especially under the influence of oxygen. (See Professor Burdach's Physiology, before quoted, vol. ix. pp. 451 and 541.)

Oily Globules.—In the chyle of the carnivora fatty or oily globules are often very numerous, and I have twice seen them in great numbers in that of man. Their appearance is very characteristic, of course varying remarkably in diameter, usually from $\frac{1}{25000}$th to $\frac{1}{2000}$th of an inch.

Minute Spherules,—probably albuminous, may frequently be seen in the chyle, as well as in the juice of the thymus, and of the lymphatic glands. These particles are very irregular in size, being generally from $\frac{1}{24000}$th to $\frac{1}{8000}$th of an inch in diameter. However numerous they may be, their varying magnitude at once distinguishes them from the uniform molecular base of the chyle; and they are not, like the latter, soluble in æther. Indeed without the aid of chemical tests, observations on any of the minuter particles of the chyle are not at all satisfactory, since many animal matters contain an abundance of little spherules, besides particles so minute that it is perhaps impossible to ascertain either their form or size, of which examples may be seen in figs. 243, 249, 258, 266, 268, 271, 272, and 279. Gruithuisen is reported by Professor Burdach (Physiologie, tom. ix. p. 455) to have seen in the chyle of the human inferent lacteals a great number of very small corpuscles, some of which became larger after passing the glands; and Professor Wagner has given an engraving of "the smaller molecules as they swim in the liquor chyli, and which probably are evolved into chyle corpuscles." He represents them to be very unequal in size, as seen with a magnifying power of 500 diameters. (Icones Physiologicæ, Tab. xiii. Fig. 2., and Physiology, part 2.)

2. Fluid of the thymus and of the lymphatic glands.

During digestion, as already described, the fluid of the mesenteric glands is pervaded by the molecular base (Figs. 277 and 278,) and is richer in globules than the chyle obtained from any other part of the lacteal system. After fasting, the molecular base entirely disappears, the number of globules, though still considerable, is much diminished, and the juice of the mesenteric glands becomes similar to that of the other lymphatic glands, (Figs. 279 and 280) viz. semi-transparent, and of a light brown tint; for although this juice contains many globules, they are not sufficiently numerous to make it opaque and creamy.

But in very young and healthy animals, the fluid of the thymus is well known to possess the last-mentioned qualities, and these are justly ascribed to the vast number of globules which it contains, for they are even more plentiful in this fluid than in that of the mesenteric glands during digestion, and indeed as abundant as the red particles are in the blood. The thymous fluid, however, like that of the lymphatic glands, is destitute of the characteristic base of the chyle; therefore, although the fluid of the thymus and the chyle are alike in colour and opacity, they differ essentially, because in the thymous fluid these characters are produced by its globules, and in the chyle by its peculiar molecular base. It is true that a finely granular matter (more or less like that depicted in the lymphatic juice, Fig. 279) and minute spherules, similar in all respects to those described in the chyle, may be found in the thymous and lymphatic fluids; but these particles, though frequently abundant, are not sufficiently copious to give opacity and colour; and, as previously noticed, the granular matter and minute spherules differ in chemical properties from the molecular base of the chyle.

The fluid of the thymus remains quite opaque and creamy when subjected to the action of æther. The globules seem to be somewhat softened after the mixture has been kept a few hours, and their shape may consequently be more or less modified; but still the thymous matter retains its usual appearance; and this, by the aid of the microscope, can be seen to be owing to the globules. The effect of æther on the lymphatic juice, of course including that of the mesenteric glands in fasting animals, is equally inconsiderable. In the following account of the action of the other tests on the thymous fluid, it is to be observed that their operation was similar on the juice of the lymphatic and mesenteric glands.

If a little caustic alkali, or a concentrated solutiou of the earthy or alkaline salts, be well mixed with a similar quantity of the fluid of the thymus, a very viscid semitransparent compound is formed, hardly miscible with water—not merely a thickening, but a stiff ropy grume is produced, much more tenacious and remarkable than the inspissation resulting from the action of a few of the above-named reagents on pus. With the exception of alum, I am not aware of one of the easily soluble salts in question, that does not quickly render the thymous juice ropy: and I find a note of a single trial in which the same effect was produced by sulphate of zinc, though several other metallic salts had no such action. A small quantity of muriatic acid produces a white precipitate in the thymous fluid, but if the acid be added in excess, the precipitate disappears and a transparent ropy matter is formed. Dilute muriatic acid causes a plentiful white precipitate. Nitric acid acts on the juice nearly in the same manner as the muriatic. The acetic, oxalic, citric, and tartaric acids either cause no change or a white precipitate in the fluid.

All the tests mentioned above, more or less affect the globules. They are dissolved by the alkalies, and either reduced to the minutest subdivisions or dissolved by the muriatic and nitric acids. The acetic and other vegetable acids act but feebly, merely diminishing the globules very slightly in size, as if from solution of the smallest quantity of matter from their surface, (see note, p. 83, 84,) In the ropy compound, formed by the thymous fluid and saline solutions, the globules soon become irregular in shape, then somewhat swollen, less distinct, and totally destroyed in the course of a day or two. It would appear, indeed, that they are dissolved by the saline solution ; and it is remarkable that reagents which preserve the integrity of the blood corpuscles should thus combine with and destroy the lymph globules.

Now the action of all these reagents is the same on the globules of the chyle and lymphatic juice ; and these globules, and the globules of the thymous fluid, are very nearly alike in structure, magnitude, and general appearance. Hence it may be inferred that all these globules are probably identical ; and if this inference should be confirmed, it must be regarded as extremely interesting, with the other facts adduced in these observations, in relation to the physiology of the glands in question.

It has been shown that the globules which are always present in the chyle and lymphatic juice, are especially copious in the mesenteric glands during digestion, and in the thymus during infancy. In short, it is probable that these glands are organs of nutrition, in which the effete matter taken up by the absorbents, and the chyle by the inferent lacteals, may undergo a second digestion or elaboration, so as to be modified and prepared to aid in the growth and preservation of the animal ; and a leading result of this elaboration is doubtless the formation of globules, perhaps as an immediate consequence of the increase of fibrine. To this end the lymphatic glands generally seem to be ever in action ; they are most developed in childhood, least so in old age. During digestion the activity of the mesenteric glands is greatly augmented, so that at this time they furnish prodigious quantities of the globules ; and the thymus, at an early period of life, is singularly rich in the like globules ; being it would seem so far merely an additional gland for the elaboration of nutrient matter, specially provided to meet the wants of the economy at the precise time when these wants are most urgent. The thymous juice too becomes scanty and thinner when the animal is ill fed or subjected to fatigue, interfering with nutrition. I have repeatedly witnessed this impoverishment of the juice in badly nourished children, in diseased young rabbits, and in over-driven lambs. In the latter, the thymus will soon shrink remarkably, and be nearly drained of its contents by bad treatment, and become as quickly distended again, during rest and plentiful nourishment with the milk of the dam. The phenomena of some diseases accord with the views expressed above. Thus scrofula, which is so prone to attack the lymphatic glands, is always attended with great emaciation when these organs become generally implicated; while this wasting is by no means so remarkable a feature of many affections of other parts accompanied with much greater alterations of structure.

The observations of Professor Müller (Physiology by Baly, Part 1, p. 263) have already shown that the globules may be formed quite independently of the lymphatic glands; besides, these latter do not exist in the lower vertebrata. But the facts already detailed surely prove that the thymus and the lymphatic glands are organs superadded to the higher animals for the production of a great quantity of globules similar to those found in the chyle, and that the activity of these organs has an immediate relation to the known exigencies of nutrition.

What is the precise agency, in the animal economy, of these globules, is a question of great interest, and well deserving of special inquiry. As I have elsewhere remarked, they are in most respects analogous to the nuclei of primary cells, (note, p. 83,) and the smaller globules are in no way distinguishable from these nuclei. If, therefore, this identity should be established, the lymph globules will prove to be so many germs for the formation of those cells which the excellent researches of Schwann have shown to be intimately concerned in the development of the animal tissues generally. And I may add, that there are but few mature tissues in which corpuscles, probably remains of these cells, may not be shown to exist. (See explanation of figs.

288—291.) In fine, that the globules of lymph may be converted into the red particles of blood seems to be generally admitted: and Professor Valentin (Wagner's Physiology by Willis, Part 1, p. 215) considers the corpuscles of both these fluids as cell-nuclei or cytoblasts. I may mention incidentally that the description given by Valentin of the facts observed by him in the larva of the frog, and from which he concludes that the blood-corpuscles are not cells but nuclei, would apply to the manner in which I have seen the minute spherules become attached to the small or irregular blood-corpuscles of mammalia, as depicted in Fig. 268.

Hewson states that the lymph globules, which he calls central particles, differ in size and shape in different animals, (Experimental Inquiries, part 3, p. 27, edited by Falconar, Lond. 1777.) Thus he has given an engraving to show the oval figure of the central particles in the common fowl. This requires further examination as to the lymph globule: but the nucleus of the blood corpuscle undoubtedly differs considerably in the lower vertebrata. In birds it is a more elongated ellipsis than the envelope, while in fish, the nucleus is nearly, often completely, circular (see Appendix, p. 30.) I have not examined the lymph of birds, but in their blood the white globular particles are known to be abundant (see Appendix, p. 24.) In the dromedary, however, an animal with oval blood discs, I found the globules of the thymous and lymphatic juice (Figs. 286 and 287) of the same form and size as in other mammals (see Lancet, April 10, 1841.) And in the Napu Musk Deer, an animal with singularly minute blood discs, my observation on the lymph globules was to the same effect (see note, p. 41.)

Hewson advanced the opinion, as the result of an admirable inquiry, that the particles of the thymous and lymphatic juice are identical, and that the thymus is accordingly an appendage to the lymphatic glands (Exp. Inq. p, 3, p. 119—131.) He incessantly enforces this conclusion: yet his excellent researches are not sufficiently known or appreciated, and often only quoted to inform us that he regarded the globules as specially designed to form the central particles of the blood corpuscles. This is not just to Hewson; for his observations, which were generally made with singular exactness and sagacity, are not to be confounded with any hypothesis in which he may be supposed to have indulged. As Sir Astley Cooper (Anatomy of the Thymus-Gland, 4to. Lond. 1832) does not appear to have made the lymph a subject of particular examination, his authority is nugatory on this subject, against the facts enunciated by Hewson. Indeed it seems doubtful whether Hewson's Physiological Researches were ever completely comprehended by his contemporaries and immediate successors.

Had he extended his inquiries to the chyle and to the mesenteric glands, he would undoubtedly have found additional reasons to confirm his conclusion as to the similarity of function between the thymus and the lymphatic glands. His notion of central particles, so long looked upon as visionary, accords with the most recent observations. What are some of the free nucleoli of Valentin and cell nuclei of Schwann (Wagner's Physiology, by Willis, part 1, pp. 215 and 222) but the central particles of Hewson? It is true that the English physiologist only applied his doctrine to the formation of the blood corpuscles. It is also certain that these in mammalia retain nothing like a lymph globule in their centre; for in this class of animals the blood discs have only a very flat central part, not at all resembling the nucleus usually described in them, (see Appendix, p. 13, 14; and Phil. Mag. for Feb. 1840, p. 106—107;) yet in the oviparous vertebrata the blood corpuscles always possess central particles similar in some respects to the lymph globules; and that acute observer, R. Wagner, has delineated a human chyle globule, " doubtless in progress of transformation into a blood corpuscle.*

G. G.

* Since the foregoing pages were printed, I have read some valuable observations on the chyle by Mr. Lane (Cyclopædia of Anatomy and Physiology, April, 1841, Art. Lymphatic System.)

CORPUSCLES OF THE LIVER.

(*Figs.* 263 *and* 264.)

These are magnified only 380 diameters in the figures, not 800 times, as stated by mistake in the explanation of the plates. The corpuscles have probably been described by Krause, Dujardin, or Verger; but I have no opportunity of consulting their writings.

The corpuscles are generally oval; for the most part $\frac{1}{800}$th of an inch in length, and $\frac{1}{1000}$th in breadth. They seem to be composed of a matrix pervaded by granular matter, and sometimes by spherules about $\frac{1}{5300}$th of an inch in diameter, though very unequal in size, many of them being much smaller, as represented in fig. 263, from a horse which died of that peculiar disease commonly called bleeding liver. In the human subject (fig. 264) the spherules are not so commonly seen attached to or forming part of the corpuscles.

In the sparrow-hawk (Nisus vulgaris, Cuv.) the corpuscles are round, and their average diameter, from measurements made by Mr. Siddall, is $\frac{1}{1684}$th of an inch.

It appears that Dr. Rees describes the albuminous matter of the chyle as of a dead white colour, which he attributes to the admixture of a peculiar substance easily obtainable by agitating chyle with æther, and also by treating saliva in the same manner. I have already mentioned that a like substance appears after mixing æther with a variety of animal matters. But my examination of the matter in question was chiefly confined to its physical characters; and it is not impossible that the abundance of spherules which it contains, as shown in fig. 282, may be only minute portions of uncombined æther. The molecules which constitute the base of the chyle, Mr. Lane denominates granules; which term would be unobjectionable, had it not been so frequently applied by other writers to particles of a different kind, as noticed in the Explanation of the Plates, p. 59.

CORPUSCLES OF THE SPLEEN.

(*Fig.* 265.)

These are mostly globular, often oval; some of them contain a nucleus, others seem to be formed simply by an aggregation of granules. The corpuscles represented in the figure were all of a dark red colour, and are apparently the red brown granules noticed by Professor Müller. (Physiology, by Baly, part 2, p. 569.) It would appear from the following measurements that the human splenic corpuscles are more unequal in size and slightly larger than the blood discs.

1—5333	Common sizes.
1—3200	
1—2400	
1—6000	Small size.
1—1777	Large do.
1—3038	Average.

The measurements, as usual, are expressed in fractions of an English inch. The corpuscles were obtained from the pulp of the spleen. They are most easily examined after the blood has been washed out with water. In the sparrow-hawk the splenic corpuscles are like those of man.

SUPRA-RENAL GLANDS.

Minute Spherules. (Figs. 266 and 267.)—The pulp of the supra-renal gland is almost entirely composed of minute oil-like spherules, very unequal in size, usually varying from $\frac{1}{24000}$th to $\frac{1}{6000}$th of an inch, their most common medium diameter being about $\frac{1}{10000}$th. They are so numerous, that it is frequently necessary to dilute the pulp to get a good view of them. For this purpose water, acetic acid, or dilute muriatic acid may be used. The smaller spherules, like other particles of similar minuteness, almost always exhibit vivid motions; (see Robt. Brown " On Active Molecules," Edinburgh New Phil. Journal, April —Sept. 1828, page 358,) and these may occasionally be seen in the undiluted juice, either taken warm from an animal just slaughtered, or after the gland has been long kept in the air. The smaller spherules often seem to repel each other, especially when diluted with water, rather than blend together, as drops of oil or mercury do.

Many re-agents that instantly act on most other microscopic particles, do not affect those of the supra-renal gland. They are not changed by nitric, muriatic, sulphurous, or acetic acids, nor by caustic alkalies, nor by earthy, alkaline or metallic salts, nor by æther. But the latter test generally makes the fluid of the gland more opaque, so that it is often necessary to dilute the mixture to bring the spherules clearly into view. They are simply rendered of a darker colour by sulphuric acid. Caustic potass frequently produces slight ropiness of the fluid, although this effect is neither caused by liquid ammonia nor by neutral salts.

The immediate operation of the tests is described above. After the strong mineral acids have been some hours mixed with the pulp of the gland, the majority of the minute spherules are no longer visible, and larger particles appear, apparently of fatty matter in a semifluid state. Some of these latter are spherical, while others are very irregular in shape. Their size is extremely variable, commonly from $\frac{1}{5000}$th to $\frac{1}{1300}$th of an inch in diameter. Similar particles result from keeping the pulp of the gland in æther; but in this mixture the proper minute spherules are abundant.

Corpuscles, or cells. (Fig. 267.)—The above observations refer to the super-renal glands of man, of the quadrumana, of the horse, and of numerous rodentia and carnivora. In many ruminants the minute spherules are less plentiful, their place being supplied by corpuscles somewhat resembling lymph globules in size, but often of a reddish colour, and occasionally of an oval figure. The corpuscles are but faintly affected by acetic acid. They are probably cells or nuclei. The corpuscles frequently occur in smaller numbers in the human subject, and the animals first mentioned, particularly in early life. In a sucking ass the corpuscles were remarkably abundant, while there were but very few of the minute spherules; and in a fœtal porpoise I could detect none of the spherules, the juice of the gland being full of the corpuscles and blood discs. The latter animal weighed ten pounds, each kidney was nearly as large as a hen's egg, and the supra-renal glands only measured half an inch in length and a quarter in breadth. In some instances in which the pulp of the gland was chiefly composed of the corpuscles, as in a fœtal calf, and in a fawn (Cervus Dama, Linn.) five days old, the action of ammonia destroyed the corpuscles, and increased the quantity of the minute spherules, as if the latter had been generated and hid by the cells.

Venous blood.—The gland has seldom a cavity, although a large and distinct venous sinus sometimes exists in the centre. In the Norway lynx, (Felis cervaria, Temm.) for instance, the sinus was very remarkable; but it was not so in the Persian lynx, (Felis caracal, Gmel.) As noticed in the Dublin Medical Press, Jan. 1, 1840, I have frequently seen in the venous blood of the supra-renal glands numerous minute spherules which could not be distinguished from those of the gland. In one instance they were copious in the supra-renal vein of a dog, which was killed by a blow on the head, a ligature being immediately put around the vein and the circulation kept up for several minutes by artificial respiration. The veins are probably the excretory ducts of the gland. Several of my observations, however, on the contents of the vein in dead animals have been very contradictory; and many careful experiments would be required to ascertain satisfactorily that the minute spherules found in the venous blood, are identical with those of the gland. The minute spherules (fig. 268) occurring in the blood of various parts, and in some other fluids, have not yet been distinguished from the particles of the supra-renal glands.

Juice in young and old animals.—The minute spherules are often as numerous in the adult as in the young animal, sometimes more so; and the glands are as large, or larger, and frequently fuller of juice in the former than in the latter. In many very young mammalia the glands are scarcely larger in proportion to the body, than those of the mother. In a woman aged seventy-four I found them twice as large as in a boy aged nine months; and the glands of the old woman were richer in the juice and its proper spherules than the glands of the child. I have not observed that their absolute size gradually diminishes after birth, as stated by Meckel (Manuel d'Anatomie, traduit par Jourdan et Breschet, t. 3, p. 592;) at least they are generally as large in the adult as in the half-grown human subject. Bichât observes (Anatomie Descriptive, t. 5, p. 462) that the glands become thinner and dryer, are shrivelled and even disappear in old age. I have often seen the glands of full size and juicy in the aged, and am led to doubt whether they commonly waste more at this period of life, than several other organs.

Situation.—In some animals the glands are more separated from the kidneys than usual. In the rabbit the glands are about three quarters of an inch distant from the kidneys; in the Musk Deer (Moschus Javanicus, Pall.) the left gland is an inch and a quarter anterior to the fore end of the kidney. In certain carnivora the glands are also more or less removed from the kidneys.

The minute spherules in the oviparous vertebrata.—I have often seen the spherules abundantly in the pulp of the supra-renal glands of some birds and reptiles. In the sparrow hawk (Nisus vulgaris, Cuv.) when the spherules were treated with acetic acid, they appeared transparent at the circumference, and opaque in the centre, as if from a single globular nucleus.

THE END.

ELEMENTS

OF

GENERAL ANATOMY.

ELEMENTS

OF THE

GENERAL AND MINUTE ANATOMY

OF

MAN AND THE MAMMALIA,

CHIEFLY AFTER ORIGINAL RESEARCHES.

BY

FR. GERBER,

PROSECTOR IN THE UNIVERSITY OF BERN.

TO WHICH ARE ADDED

NOTES AND AN APPENDIX,

COMPRISING OBSERVATIONS ON THE BLOOD, CHYLE, LYMPH, THYMOUS FLUID, TUBERCULAR MATTER, EPITHELIAL CORPUSCLES, &c. &c.

BY

GEORGE GULLIVER, F.R.S.

ATLAS

CONTAINING THIRTY-FOUR PLATES, ENGRAVED.

LONDON:

HIPPOLYTE BAILLIERE, 219, REGENT STREET,

FOREIGN BOOKSELLER TO THE ROYAL SOCIETY, AND TO THE ROYAL COLLEGE OF SURGEONS.

PARIS: J. B. BAILLIERE, RUE DE L'ECOLE DE MEDICINE.

LEIPSIG: T. O. WEIGEL.

M.DCCC.XLII.

ADVERTISEMENT.

These Figures illustrative of my Elements of General Anatomy I have, with a few exceptions, drawn from Nature with my own hand. I do not pretend that they have won anything as works of art from this; but I had no choice; and I believe them to be faithful. Their great defect, in my own eyes, is a want of the natural delicacy which the structures represented possess,—a delicacy, indeed, which no human hand can hope to emulate. However ready to acknowledge their want of artistic merit, then, I can nevertheless say that they are the product of many an hour that would else have been an hour of relaxation.

A few repetitions, in consequence mainly of the introduction of the Table of Terminology, will have to be pardoned. I thought it well to present a general and comprehensive view of the elementary forms of the component parts of animals, to show their affinities, and to trace the passage, by gradual evolution, into more highly organized forms, and finally, the essence of their complete metamorphosis first, and then of their degeneration till they are felt as no longer serviceable to the organism in its totality.

With regard to the means of research and observation at my command, I havė, through the kindness of the owners, had the use, for longer or shorter periods, of the following microscopes :—

1. An instrument by Schiek and Pistor, the property of Professor Valentin; an admirable instrument, well known and celebrated among microscopic observers.

2. An instrument by Plössel, belonging to Dr. Seiler.

3. A microscope by Chevallier of Paris, the property of Dr. Baswitz.

4. An English microscope, name of the maker unknown to me, the property of M. Von Werdt-Steiger.

All these instruments, except the last, are achromatic; one of them is, in addition, provided with a screw micrometer and cross wires; and two with sets of double glass micrometers, the one having the line divided into 30, the other having it divided into 60 parts. Some of my older observations, and among my more recent ones, those having reference to the structure of the nerves, were made with my own microscope, which is one of the better non-achromatic old-fashioned instruments. The compressor and the double knife I found at times of essential service. Among chemical reagents, solutions of common salt, of caustic potash, of carbonate of potash, and of sal ammoniac, as also acetic acid, oil of turpentine, sulphuric ether and alcohol, were frequently employed.

The true dimensions of the microscopic objects, and their apparent magnitudes as indicated in the Figures, were determined by the simplest and most certain methods, either by means of the screw micrometer, or of one of the glass micrometers placed under the eye-piece. To use the latter conveniently and assuredly, I fell upon the following plan: I placed in the focus of the eye-glass one of the glass plates having the line divided into 30 parts, and in the focus of the instrument at large one of the glass plates having the line divided into 60 parts; I then determined with the greatest nicety the number of degrees upon the under (60 to the line) plate which were comprised within a single degree of the upper (30 to the line) plate. Suppose these under the lowest power—eye-piece No. 1, object-piece No. 1—to amount to 5°, then one degree of the upper micrometer measures, $\frac{5}{60}$, or 1-12th of a line; an object, therefore, that measured 3° in length of the upper micrometer, would have an absolute length of 3-12ths or 1-4th of a line. With higher powers, of course many degrees of the upper micrometer are included in one of the lower, for instance, 30 in 1. The true length of an object which measured 1° of the upper micrometer would then be $\frac{1}{30} \times 60 = \frac{1}{1800}$th of a line; did it measure 5°, it would then be $\frac{5}{30} \times 60 = \frac{5}{1800} = \frac{1}{360}$ of a line; and so on. By means of a Table constructed upon these data, all dimensions are readily ascertained with celerity and precision.

I take the present opportunity of publicly expressing my thanks for the readiness with which the friends I have mentioned favoured me with the use of their costly instruments; my more particular acknowledgments, however, are due to my honoured colleague Valentin; ever ready to oblige, ever actively engaged himself, and ever glad to aid research in all within the sphere of his influence—may he long continue to adorn the school upon which he now sheds so bright a lustre!

FR. GERBER.

BERN, 1840.

GENERAL ANATOMY.

SKETCH

OF A

SYSTEMATIC TERMINOLOGY IN REFERENCE TO GENERAL ANATOMY;

OR,

AN ATTEMPT TO DESIGNATE APPROPRIATELY, AND TO DIVIDE SYSTEMATICALLY, THE ELEMENTARY CONSTITUENTS OF ANIMALS, INCLUDING A PARTICULAR EXPLANATION OF THE FIGURES FROM FIG. 164 TO 238.

I. UNORGANIZED CONSTITUENTS, THE FORMS OF WHICH DEPEND ON GENERAL PHYSICAL AND CHEMICAL FORCES.

1. *Liquid with the globular form.*

GUTTULA, a drop, a globule. Figs. 164—168; the objects seen by transmitted light.

Fig. 164. A flattened round drop, adhering to the port-object, in this instance a plate of glass.

— 165. An elliptical-shaped drop, under the same circumstances.

— 166. A free globular drop, its lowest point in the focus of the microscope.

— 167. A similar drop, its centre in the focus.

— 168. A similar drop, its highest point in the focus.

— 169. A drop of the same description seen by reflected light falling laterally.

Example.—Oil or fat-globule:

In milk. Fig. 22.
In chyle. — 23 B.
In sebaceous matter of the skin. Fig. 31 e.

(Bubbles of air in a liquid might with propriety be referred to this head.)

2. *Solid; a. Crystalline.* These are generally objects having a regular figure bounded by flat surfaces, and rectilinear edges and angles.

Crystalli, crystals. Fig. 170—176.

Fig. 170. A four-sided table.
— 171. A cubical crystal.
— 172. A lozenge or rhomboidal horny plate, such as in disturbance of the cerebral functions is often seen formed in the choroid plexus of the horse.
— 173. A three-sided prism.
— 174. A six-sided prism pointed at one end.
— 175. A three-sided pyramid.
— 176. Acicular crystals.

Examples.—In fluids:

In the fluid of the allantois. Fig. 30 B.
In the sebaceous matter of the skin (crystals of stearine, horse.) Fig. 31 d.
In solids:
In firm exudation. Fig. 30 A.

——— *b. Non-crystalline, globular or rounded.*

Glarea, gravel, grit, sediment. Hard globules and granules.

Fig. 177. Gravelly globules.
— 178 Gravelly granules.
— 179 Mulberry-like gravel.

Examples.—The urinary sediments and grit of the Solidungula. Fig. 29.

The grit of the choroid plexus of the brain.
The grit of the pineal gland.

II. Imperfectly organized, amorphous, transparent, solid, homogeneous substances, which generally contain cells, nuclei, or canals.

Substantia vitrea s. hyalina, vitreous or hyaline substance.

a. Not including cells or nuclei:
Pulp of the navel string.
Fibrine at the moment of its coagulating.
The crystalline lens.

b. Including cells. Fig. 216.

Examples.—Hyaline substance of the cellular cartilages. Fig. 53 B, fig. 57 A.
Hyaline substance of reticulate cartilages. Fig. 59.

c. Including nuclei or nucleoli.

Example.—Cartilage of bone. Fig. 60 and 61 a.

d. Including canals or tubuli.

Example.—Cartilage of the teeth—hyaline substance of the tubular structure. Fig. 68 k.

III. Highly organized animal structures. Simple and compound organic elements of the animal body, the forms of which are the effects of the organizing force (the formative vital power.) Fig. 180—207.

1. Simple or elementary constituents; not susceptible of subdivision into dissimilarly organized parts.

A. Plates or flat formations. Fig. 180—186.
a. Simple.
aa. More minute, with rounded boundaries.

Squamæ s. squamulæ, plates or scales. Horny cells without nuclei.

Fig. 180. Six-sided plate or scale.
— 181. Eight-sided plate or scale.
— 182. Elliptical plate or scale.
Three, four, and five-sided squamæ.

Example.—Horny plates of the horn of the ox. Fig. 34.

Scales from the conjunctiva (horse.) Fig. 41 a.

b b. Larger, with various, not predominating linear boundaries.

LAMINULÆ. Fig. 183.

Example.—Large cells without nuclei.

c c. Long, linear.

FILA TÆNIOFORMIA S. TÆNIOLÆ. *a.* Simple band-like or flat fibre. Fig. 184.

Example. The flattened fibre, of elastic tissue. Figs. 54—56.

The involving, spiral fibre of the primary voluntary muscular fasciculus in the dog. Fig. 29, 2 b, 3 b, 4 c.

b. Compound flat fibrous formations, made up of several flat fibres.

FIBRA SQUAMOSA, squamous fibre. *Fibra tæniolaris,* flat fibre. Allineated squamæ, or squamæ hanging together in a line. Fig. 185.

Example.—Fibrous horn. Fig. 34 B.

FUNICULUS TÆNIOLARIS. Flat filamentous cord;—parallel flat filaments bound together.

Example.—Fig. 79, 3 b.

FUNICULUS FIBRO-SQUAMOSUS. Fibro-squamous cord: parallel squamous fibres bound together.

Example.—Fig. 34 B.

MEMBRANA S. CUTICULA SQUAMEA SIMPLEX. Simple or unilamellar membrane,—squamæ arranged superficially. Fig. 186.

Example.—Fig. 41 b.

MEMBRANA SQUAMOSA COMPOSITA. Compound or multilamellar membrane,—superficially arranged squamæ, one layer lying over another.

Example.—Fig. 41, c, and 40 e, f.

The flat filamentous bundle.

The flat fibrous bundle.

The flat filamentous membrane.

The flat fibrous tissue, and so on, vide fig. 194 to 201.

B. Rounded homogeneous soft solids.

a. Simple, peripheral.

Granula, granules ; aggregated granules. Small, soft, rounded, simple formations. Fig. 187—192.

Examples.—Lymph granules. Fig. 7 b, fig. 23 B, b. Granules of the cyst-corpuscle (multigranular pus-corpuscle.) Fig. 9 c.

Attached granules. Fig. 10 upon c, d, and l.

Fibrinous granules. Fig. 23 A.

Granules of coagulated milk. Fig. 23 A.

Mucus-granules. Fig. 25 A, d and B. fig. 48 D.

Seminal granules. Fig. 26 A.

Pigmentary granules. Fig. 32, 1. and fig. 39 d.

Ganglionic granules (ganglionic cells.) Fig. 89. 2, 3, 4. fig. 89, 1 and 7.

Granules of the granular muscles of organic life (?) Fig. 74.

Granules of the fibres of the muscles of animal life (?) Fig. 82.

Globuli, globules. Smooth, spherical granules. Fig. 188.

Example.—Seminal globules. Fig. 26 A.

b. Compound, consisting of many granules stuck together. Fig. 189—192.

Corpuscula granulosa s. granulata, granular or granulated corpuscles. Aggregation corpuscles; rounded corpuscles having no nucleus, made up of granules. Fig. 190.

Examples.—Cyst-corpuscle (multigranular pus-corpuscle.) Fig. 9 c, fig. 10 e, f, l.

Mucus-corpuscle. Fig. 25 B.

Corpuscle of the Graafian vesicle (?) Fig. 27 b, fig. 28 a.

Pigmentary corpuscle. Fig. 32, 1 a.

Fibra granulosa s. granulata. Granular fibre. A fibre consisting of simple granules arranged in lines. Fig. 189.

Example.—The fibre of the granular muscles. Fig. 74 a, and fig. 82 A. B.

Membrana granulosa. Granular membrane. Granules arranged in the same plane. Fig. 192.

Example.—The inner lamina of the retina.

c. Simple, rounded, central, productive granules (germ granules.)

Nucleolus, nucleolus. (Kernchen, G.) Central grain. A simple granule included in a nucleus (cell-germ.) Fig. 193.

Examples.—Nucleus (properly nucleolus) of the blood corpuscle. Fig. 1 b, fig. 2 c, fig. 205, 1 b.

Nucleolus of the true, healthy, reproductive or seven granular pus corpuscle. Fig. 9 b, fig. 10 g, fig. 205, 3.

Nucleus (properly nucleolus) of the exudation corpuscle. Fig. 9 a, fig. 10 i, fig. 205, 2.

Nucleoli of cells generally. Fig. 215 e, fig. 217 b, fig. 220 b, fig. 226 c.

Nucleolus of the cartilage-cell. Fig. 217 b.

Nucleus, nucleus or kernel. (Kern. G.) A simple central grain, granule, or globule, without a nucleolus, surrounded immediately by a cell. Fig. 202 a, b.

Examples.—Nucleus of the epithelial-cell. Fig. 25 A, in a, a, a. The white point in the pigmentary cells of the choroid coat of the eye. Fig. 32, 2 and 3 b; fig. 33.

Nucleus of the cartilage cell. Fig. 59 b, b, b, fig. 217 a.

Nucleus of the bone-cell or bone-corpuscle. Fig. 61 a, fig. 62 a, fig. 63 a, fig. 68 d, fig. 70 a.

Nuclei of cell and ciliary corpuscles. Fig. 48 g.

Nucleus granulosus, granular nucleus. A nucleus composed of granules; probably a granular nuclear corpuscle, as that of the true pus corpuscle. Fig. 217 g, fig. 218 a, b, c, fig. 223 b.

Example.—Common, perhaps constant, in cartilage cells. Fig. 57 c. In the cell-fibres of the sheaths of nerves and vessels. Fig. 102 at d.

C. Cylindrical, simple, linear formations.

a. Fila rotunda s. cylindrica. Simple rounded filament. Fig. 194.

Example.—Fibre of cellular substance. Fig. 19 b, fig. 73 c.

Fibre of tendon. Fig. 51 +.
Fibre of ligament. Fig. 52.
Fibre of one variety of cartilage. Fig. 53 A, a.
Fibre of contractile tissue. Fig. 73 b.

b. Compound, round, filamentous formations—compounds of many round filaments.

Fasciculus filorum. A bundle of filaments—a cylindrical filamentous cord. Fig. 195.

Funiculus filorum. A round filamentous cord. Round filaments connected parallel to the length of the cord. Fig. 196.

Examples.—Cord of the filaments of cellular substance. Fig. 19.

Cord of tendious filaments. Fig. 51 b, c.
Cord of ligamentous filaments. Fig. 52.
Cord of cartilaginous filaments. Fig. 53 A.
Cord of contractile filaments. Fig. 73 a, a, a.

Membrana filorum. A filamentous membrane. A membrane composed of filaments lying parallel to each other. Fig. 200.

Example.—Serous membrane. Fig. 49 A.

Contextus filorum. A filamentous tissue. A structure composed of filaments. Fig. 197.

Example.—Tissue of cellular substance. Fig. 49 B.
Tissue of contractile filaments. Fig. 75, at b. and c.

Rete filorum. A filamentous net. Fig. 198, fig. 225 (?)

Example.—Elastic tissue (?) Fig. 54 a.

Filorum implicatio regularis. A grating of filaments. Fig. 199.

Example.—Fig. 76 A (?)

Contextus fasciculoso-filosus. A tissue of filamentous fasciculi. Fig. 201.

2. More highly organized proximate or compound constituent parts, in which dissimilar structures are distinguishable.

A. Binary. Composed of two simple elements.

a. Uniform structureless substances, forming simple investing covers.

α. Rounded.

Vesicula s. bullula simplex s. primitiva. A simple vesicle. An unnucleated cell. A simple hollow globule, or globular cuticle including structureless substances, fig. 208; heaped together, fig. 209. Including serum;

The serous vesicle, which occurs every where in the moist cellular substance.

Including fat:

The fat vesicle; occurs universally in the adipose cellular substance.

Example.—Round fat vesicles. Fig. 31 a, b, c.
Crowded (multilocular) fat vesicle. Fig. 71 and 72 b, and fig 94 s.

α. β. Transition of the simple vesicle into the simple hollow fibre (simple vessel.)

Vesicula pedunculata simplex. Pedunculated simple vesicle. Fig. 208.

Example.—The vesicle of the epithelial corpuscle (?) for example, of the intestinal villus. Fig. 240 c, d, and fig. 241 b.

Vesicle of the sebaceous glands. Fig. 42 n, o, p, fig. 43 e, fig. 44 e, fig. 45 e.

Vesicle of the sudoriparous glands. Fig. 43 i, i.

Vesicle of the Meibomian glands. Fig. 158 c.

β Elongated, siliquose, simple, hollow envelope, with uniform contents.

VASA SIMPLICIA. Simple vessels with homogeneous contents. Fig. 213.

Example. The most delicate peripheral or efferent lymphatic vessels. Fig. 108; a, a, in fig. 113; fig. 141.

The excretory ducts of the cutaneous glands: viz.

Of the sebaceous glands. Fig. 36 e, f, fig. 37 a, a, fig. 40 g, h, fig. 42 d, d, fig. 43 f f, fig. 44 c, fig. 45 d, c, fig. 160, fig. 161, fig. 239 d, e, f.

Of the sudoriparous glands. Fig. 43 k, k.

The sheaths of the hairs. Fig. 42 c, fig. 43 and 45 c.

The tubuli of the ivory in the teeth. Fig. 68 f, i, k, l.

Horny tubes, with simple solid contents:

Pili, hairs. Fig. 42 k, l, m, fig. 43 h. fig. 45 f, fig. 94 r.

Soft moveable hairs:

CILIA VIBRATORIA. Vibratile cilia.

Of the ciliary cells. Fig. 221 d, fig. 222 c.

Of the ciliary corpuscles. Fig. 48 d.

Of the ciliary cellular fibres. Fig. 223 at a, and fig. 224 at b.

b. Organized simple formations; simple, including envelopes:

α. Rounded.

NUCLEUS NUCLEOLATUS. Nucleolated nucleus. (Schachtelkern, G.) A nucleus with an included nucleolus. Figs. 204—206.

Example.—Blood corpuscles. Fig. 1—6, fig. 10, a, b.

Lymph-corpuscles. Fig. 7, fig. 4 a.

Exudation corpuscles. Fig. 9 a, fig. 10 i, k.

Ichor corpuscles. Fig. 9 d, fig. 10 c, d.

CELLULÆ NUCLEATÆ. Nucleated cells. (Kernzellen, G.) Simple cells without nucleoli. Figs. 214, 216, 227.

Example.—Simple epithelial cells. Nucleated cells of the epidermis and epithelium. Fig. 25 A, a, a, a, fig. 47, fig. 103 b, b, b.

Pigmentary cells of the choroid coat of the eye, fig. 32, 2, 3.

Bone cells. Fig. 86 b, b'.

Nucleated cells in cellular cartilage. Fig. 57 b, c, fig. 58; and mingled with nucleolo-nucleated cells, and binucleated cells. Fig. 217 a.

Nucleated cells in reticulate cartilage. Fig. 59 b, b.

Compound nucleated-cellular formations.

FIBRÆ CELLULOSO-NUCLEATÆ. Cellulo-nucleated fibres. Fig. 218, fig. 219.

Example.—In the second stage of the secondary fibrous organization. Fig. 17.

The cellulo-nucleated fibres of the nervous sheaths. Fig. 102 c, c, fig. 103 c, d, e.

The cellulo-nucleated fibres of the vascular sheaths. Fig. 103 d, d.

MEMBRANA CELLULOSO-NUCLEATA S. EPITHELIUM CELLULOSO-NUCLEATUM. Cellulo-nucleated membrane or epithelium. Fig. 214, fig. 215 a.

Example.—Outer skin (epithelium) of the mucous membranes, ex. gr. Of the allantois. Fig. 103 b, b, b.
Of the conjunctiva. Fig. 47 and farther,
Of the choroidea. Fig. 32, 2, and fig. 33.

B. Ternary, organized, constituent parts. Parts with three different elementary constituents.

1. Simple coverings, including contents of two dissimilar kinds.

a. Rounded, with organized contents:

CELLULÆ NUCLEO-NUCLEOLATÆ. Nucleo-nucleolated cells. (Schachtelzellen, G.) Cells with included nucleolated nuclei. Fig. 215 at c, fig. 217 b, c, fig. 220, fig. 226.

Example.—Ganglionic cells, ganglionic globules. Fig. 89, 2, 3, 4.

Nucleo-nucleolated cells (encased cells) of cartilage.

Nucleo-nucleolated cells of the external indusiæ (epidermis, epithelium.) Fig. 226 a, b, c.

b. Elongated, with contents of two kinds, partly organized.

VASA SIMPLICIA CONTENTO DUPLICI USA. Simple vessels, with contents of a twofold nature. Corpuscles suspended in a fluid.

Example. The capillary bloodvessels. Fig. 6 A, b, b, b, fig. 20, fig. 21 c, d, e, fig. 132—135, fig. 136 c, c, fig. 137—152, fig. 153, fig. 155 c.

Canals of the bones—the most delicate bloodvessels of the bones. Fig. 61 b, c, fig. 62 b, fig. 68 e.

2. Bitunicated canals with homogeneous contents.

a. With a simple cellular external coat.

All the finer secretory canals furnished with a mucous membrane (VASA SECRETORIA CAPILLARIA, the capillary secretory canals.)

Example.—The tubuli of the kidney.

The finest subdivisions of the biliary ducts.

The finest subdivisions of the salivary ducts. Fig. 156 and 157.

The finest subdivisions of the lachrymal ducts.

The finest subdivisions of the Meibomian ducts. Fig. 158.

The finest subdivisions of the prostatic ducts.

The finest subdivisions of the Cowper's glands, and so on.

b. With a ciliate epithelium or external coat.

FIBRÆ PRIMATIVÆ NERVORUM. Primary fibres of the nerves. Fig. 88, 4; *a.* Neurelema, or immediate investing coat; b, Ciliate external coat; b, b, The coagulated contents.

C. Quaternary, compounded, organized constituents. Parts made up of four simple but different elements.

1. Bitunicated, with contents of two descriptions.

a. Rounded.

OVUM, OVULUM. The primary egg before fecundation.

(Eichen, Eibläschen, G.) Fig. 27. Made up of the double envelòpe or covering. *c.* The vitelline membrane, and *d,* the exochorion or zona pellucida, which include *e,* the vitellus or yolk, and *f,* the germinal vesicle.

a b. Transition from the rounded to the elongated form.

VESICULÆ PEDUNCULATÆ COMPOSITÆ. Pedunculated, compound vesicles.

Example.—The pulmonary vesicle or vesicles. Fig. 159 (Cover:—the mucous membrane, and cellular epithelium; Contents—a muco-aqueous fluid and air.)

b. Elongated.

VASA COMPOSITA. Compound vessels. Vessels having two tunics, and contents of two different descriptions.

Example.—The central or efferent lymphatic vessels. Fig. 108 b, e, f.

The venous lymph-ducts. Fig. 110 a, 111 b, e, 112 b, c.

The interglandular lymphatics. Fig. 109 a.

(Cover:—A muscular fibrous tunic, and a serous tunic; Contents—Lymph-corpuscles and lymph-fluids.)

The bloodvessels:

The veins. Fig. 14—120, fig. 136 d. (Cover:—An organic, muscular, fibrous coat, and a serous coat; Contents—Blood-corpuscles and blood-fluid or liquor sanguinis.)

The arteries. (Cover:—An elastic tissue, or coat, and a serous coat.) Contents—Same as the veins.)

The excretory ducts of such glands as the

Salivary glands,

The liver,

The testes,

The lachrymal glands,

The mammary glands, &c. which are lined throughout with a mucous membrane, and of which the cover or bounding parietes consist of this membrane with a supercomposed cellular epithelium, and the contents are mucous corpuscles and granules, oil-globules, or watery fluid, &c.

EXPLANATIONS

OF THE

PLATES.

Fig. 1—21. Blood.

— 1—14. Blood-corpuscles, globules or discs.

— 1—6. Blood corpuscles of vertebrate animals.

— 1. Blood corpuscles of the fish, (the barbel, *Cyprinus barba.*)

a. The capsule (nucleus); *b.* the nucleus (nucleolus.)

Fig. 2. Blood-corpuscles of the reptile (newt or triton) magnified 450 diameters.

Fig. 3. Blood-corpuscle of the bird (pigeon) magnified 450 diameters.

Fig. 4. Blood corpuscle of the mammal (horse) magnified 450 diameters.

a. A lymph globule; *b.* two blood-corpuscles standing on their edges.

Fig. 5. Blood corpuscle of man, magnified 530 diameters.

— 6. Blood corpuscles of the newt in the capillary vessels, magnified 35 diameters.

a. Final subdivisions of the arteries; *b b b.* Capillaries with single rows of blood-corpuscles; *c.* Passage into the first divisions of the veins. The arrows indicate the course of the blood in the capillaries.

B. Sections of blood-corpuscles.

1. Section of a meniscus-shaped blood-corpuscle of the spider.

2. Section of a blood-corpuscle of the frog with eliptical nucleus (nucleolus) rising above the general level of the corpuscle.

3. Section of a dried blood-corpuscle of the pigeon. In the middle a round nucleus is perceived, in the circumference of which the nucleus has sunk in. The other two eminences are formed by the periphery of the nucleus, which rises in the guise of a ring above the capsule.

4. Section of a blood-corpuscle of a mammal.

Fig. 7. Lymph-globules of a mammal (horse) magnified 450 diameters, from the pale lake-coloured lymph of the thoracic duct.

a. Lymph-globule, clearer and smaller than the blood-globule (vide fig. 4.)

b. Lymph-granules, produced by the coagulation of the lymph. *c.* Lymph-globule resting on its edge.

Fig. 8. Columns of blood-corpuscles of a mammal (horse) in apposition by their flat surfaces, magnified 450 diameters.

a. Columns. *b.* Single blood-corpuscles resting on their edges. *c.* Single blood-corpuscles lying flat.

Fig. 9. and 10. Nuclear and granular corpuscles of different kinds.

Fig. 9. Corpuscles of blood (blood-corpuscles) of coagulable lymph (exudation-globules,) of pus, (pus-globules,) of cysts, (cyst-globules,) of ichor, (ichor-globules,) magnified 450 diameters.

a. Exudation-globules, which arise when the fibrine of transuded blood or lymph (plasma, liquor sanguinis) coagulates in contact with the living tissues. * Out of the body, or after death, instead of proper exudation-globules, granules are formed (*vide* fig. 15 *b.*) At first exuda-

* But without forming cells, as happens with regard to the layer that is immediately in contact with the living tissues.

tion globules look extremely like blood-globules, they then split or divide into six or seven pieces, and undergo transformation into pus-globules.

b. Pus-globules, (true pus-globules, seven granular, productive pus-globules,) of which laudable or productive pus almost entirely consists. In the true pus-globule six or seven granules surround the smaller and rounded nucleus, which in some of the globules appears to be farther subdivided into from two to four granules.

c. Cyst-globules; unnucleated, highly granular pus-globules, often much larger than the nuclei of these last. These cyst-globules are encountered in close cavities, the products of morbid action—in cysts—and are generally mingled with crystals, &c.

d. Ichor-globules. These are met with in the discharge from ulcers, in the matter of glanders, &c. They appear to be altered blood and exudation-globules, which are incapable of forming either granulations (cells) or pus.

Fig. 10. Corpuscles of blood, pus, coagulable lymph, and ichor, magnified 1300 diameters.

a. A blood-globule of a mammal (horse) seen on its flat surface.

b. The same seen from the edge.

c. Ichor-globule (glanders) with attached granules.

d. The same seen from the edge.

e. The flat highly granular cyst-globule.

f. The same seen from the edge.

g. The flat, true pus-globule, (the seven granular, laudable, or productive pus-globule,) the variety with quadrigranular nucleus.

h. The same standing on the edge.

i. Exudation-globule, which has become fissured, and is about to change into a pus-globule.

k. The same standing on its edge.

l. The rounded cyst-globule, (multigranular, round pus-globule,) with adhering granules. The cyst-globule is generally much larger than any of the other globules. Cyst-globules are encountered most frequently in the cysts of glandular structures ; for example, in those of the thyroid body. (See fig. 9 *c.*)

Fig. 11—14. Peculiarities presented by blood coagulating out of the body.

Fig. 11. Blood received into a cup, coagulating. The blood-globules are equally distributed through the coagulating plasma, or liquor sanguinis.

Fig. 12. The same blood completely set or coagulated.

a a. The serum, which has transuded, and now completely surrounds the coagulum.

b. The coagulum or cruor. The blood-globules are surrounded by coagulated fibrine.

Fig. 13. Blood mixed with sugar, coagulating. The coagulation being delayed, as it is in this instance, the blood-globules, which are specifically heavier than any other constituent of the blood, sink towards the bottom, and a clear layer of fibrine, *b*, is formed on the upper part of the coagulum, *c.* *

Fig. 14. The same blood completely set.

a a. Serum. *b.* Layer of pure fibrine (buffy coat, inflammatory crust.) *c.* The precipitated blood-globules, now occupying a smaller space, and, with the smaller quantity of fibrine with which they are mingled, forming a very deep-coloured coagulum.

Fig. 15 A. Coagulated fibrine in strings, procured by switching a quantity of freshly let blood with a rod.

a. The rod. *b b.* Club-shaped masses. *c.* Filiform and *d.* Looped fibres.

B. Granular fibrine, which has set out of the body. Magnified 100 diameters.

Fig. 16—21. Fibrine which has set under the influence of the vital power ; organization of the same.

* The formation of the buffy coat depends on something more than this. It often does not appear on blood that coagulates slowly ; and, on the contrary, it is thick on that which sets within the usual time. Very recently it has been maintained that the buffy coat is connected in every instance with a diminution in the specific gravity of the blood.—Ed.

Fig. 16. Plan figure; progress of organization in the fibrine composing coagulable lymph, (exudation of the liquor sanguinis without admixture of blood-globules,) deposited on serous and synovial membranes, &c.

a. Fluid fibrine in the form of drops. *b.* A piece of consolidated but still amorphous fibrine.

c. Exudation corpuscles (fig. 9 *a.*) not sufficiently magnified to bring the nuclei into view—*first stage of the organization.* *d.* Associated cell-bundles, more highly magnified than in fig. 102 *c d,* 103 *d d*, and figs. 218 and 219—*first stage of the fibrillation.* *e.* Associated cylindrical fasciculi—*second stage of fibrillation.* *f.* Divided or disgregated cylindrical fasciculi as they appear in the fibrils of cellular membrane, of sinews, &c.—*complete fibrillate organization.*

Fig. 17. Secondary organization in coagulable lymph. Loops and lancet-shaped leaflets—exudation villi formed of aggregated cell-fasciculi (as in fig. 102 *c.*) The liquor sanguinis (coagulable lymph) has exuded upon a portion of inflamed peritoneum. The organization has here passed the first and has reached the second stage, or the commencement of fibrillation. A specimen of secondary organization in false membranes. From a mammal (the horse.)

Fig. 18. Second stage of fibrillation in a mass of exudation from the peritoneum—aggregated cylindrical fibrillation.

Fig. 19. Secondary round fibrils (fibril of cellular membrane, and transformation of this into the fibril of sinew.)

a. Bundles and strings of the fibrils of cellular membrane.

b. Strings of the fibrils and single fibrils of sinew.

Fig. 20. Secondary formation of bloodvessels in villi of coagulable lymph.

Fig. 21. A portion of another leaf-like villus of exudation, with the bloodvessels more highly magnified.

a. Artery running into the middle of the mass.

b. Vein lying near it.

c. Capillaries of the vein.

d. Capillaries of the artery.

e. Capillaries or intermediate vessels forming the peripheral vascular rete.

Fig. 22—26. Secretions from the blood with organized constituent elements, and unorganized precipitates.

Fig. 22. Healthy milk, magnified 450 times (from the cow.)

Fig. 23 A. Abnormal milk: slimy, imperfectly coagulated, reddish-coloured milk, (from a cow which had died of the poll-evil,) magnified 200 times.

a. Milk-globules connected together by a thick fluid.

b. Scattered milk-granules.

B. Milky chyle from the mesenteric lacteals of a dog which had been fed upon horse-flesh.

a. Oil-drops.

b. Lymph-granules.

Fig. 24. Detached epithelial corpuscles (epidermic cylinders) of the bile of man and different animals. With these figures compare fig. 46, and also fig. 48. The objects are here seen under a better microscope than those of fig. 48, but they are without ciliæ.

a. In the bile of the human subject.

b. In the bile of the horse.

c. In the bile of the ox.

d. In the bile of the hog.

e. In the bile of the dog.

Fig. 25. Mucus.

A. From the mucous plug of the cervix uteri, magninified 450 diameters.

a. Epithelial cells from the epithelium of the mucous membrane of the cervix uteri.

b. Perfectly horny scales.

c. An epithelial body with ciliæ.

B. Mucous corpuscles and granules, magnified 100 diameters.

Fig. 26. Seminal fluid of different vertebrata.

A. Seminal animalcules or spermatozoa, and seminal granules of man and the mammalia.

a. Of man.

b. Of the bear (this observed by the best microscope resembles fig. 231.) The tails of the spermatozoa were not perceived in this instance.

c. Of the common mouse.

B. Spermatozoa (in packets or nests) and seminal granules in birds.

a. The spermatozoa.

b. Seminal granules including nuclei.

c. Cysts full of young spermatozoa.

Fig. 27 and 28. Contents of the ovary in the unimpregnated state.

Fig. 27. Magnified view of the Graafian vesicle or follicle (of the cow.)

a a. The membrane of the Graafian vesicle.

b. The granular follicular corpuscles.

c—*g*. The ovum.

c. The outer covering of the ovum—*Exochorion*, or *Zona pellucida*.

d. The inner investment of the ovum—*Endochorion*, or vitelline membrane.

e. The finely granular vitellus or yolk.

f. The germinal vesicle.

g. The germinal spot.

Fig. 28. Graafian vesicles from the ovary of a fœtal calf of four months.

a. Substance of the ovary—*Stroma*.

a'. An isolated vesicle covered by the ovarian stroma.

a''. and *a'''*. Smaller Graafian vesicles projecting from the surface of the ovarian stroma.

When the ovarian stroma is removed, the ovum, with its germinal vesicle and spot, is brought into view.

Fig. 29, 30. Crystalline deposits in various fluids.

Fig. 29 A. Yellowish-gray precipitate—gravel from the bladder of a male ass.

a. A globule split by pressure into three pieces.

B. Globular precipitate—gravel from the pelvis of the kidney of the horse? (Pferdewallachen, G.) The globules are smaller and fewer in number.

a. An agglomerated heap of deposit.

Fig. 30 A. Crystals of sulphate of lime in fibrine after exudation of coagulable lymph into the thoracic cavity of the horse.

a a. A linear rank of these crystals. Magnified 120 diameters.

b. Various clusters of the same crystals. Magnified 400 diameters.

B. Crystals from the fluid of the allantois of the horse.

Fig. 31. Fat of the horse. Magnified 50 diameters.

a. Fat vesicle from the pappy layer of fat within the spinal canal.

b. Fat vesicle from the cavity of the orbit.

c. Vesicle with transparent oily fat—elain vesicle.

d. Crystalline fat—tallow, stearine; and

e. Globular drop of viscid brown elain, both from the prepuce of a horse? (Pferdewallachen, G.)

Fig. 32 and 33. Black pigmentary matter.

— 32, 1. Pigmentary corpuscles and pigmentary granules.

a. A pigmentary corpuscle entire.

b. A pigmentary body, resolved into its constituent parts.

c. Pigmentary granules.

2, 3. Pigmentary cells of the choriod coat, of the ox's eye.

2, *a.* Meshes of the intercellular rete, after the removal of the pigmentary cells, under a power of 170.

3. A single pigmentary cell—a nucleated pigmentary corpuscle, magnified about 400 diameters.

a. The lamellation of the layers, which cover one another like steps.

b. The clear nucleus of the cell.

4. Different other forms of the pigmentum nigrum.

a. Elongated.
b. Radiated.
c. Asteroid.
d. Reticulated.
} Pigmentum nigrum.

Fig. 33. A portion of the tunica choroidea or vascular tunic of the ox's eye, magnified 56 times.

a a a. Veins of this tunic, covered by a single layer of pigmentary cells.

b. Arborizations of the veins in the neighbourhood of the ciliary ligament, covered with pointed and reticulated pigment.

c. Thick pigment in the vascular meshes.

Fig. 34—45. Horny tissue.

— 34 Elementary parts of horn. Slice of the horn of the ox, of the greatest possible delicacy. Magnified 400 diameters. (With this compare the horn of the fœtal ox, in the cells of which nuclei and nucleoli are still apparent, fig. 226.)

A. Elementary plates or lamellæ of the transparent, colourless, hyaline horn.—Cells transformed to horn, the nuclei of which have disappeared.

B. Plates arranged in rows or bundles,—fibrous horny tissue.

Fig. 35. A thin layer, cut parallel with the axis from the tip of the horn of an ox. Magnified 100 diameters.

a a. Clear hyaline horn.

b b. Deep brown pigmentary spots, which occur in the coloured parts of streaked horn.

c. Vascular canal, in the middle of the tip of the horn.

Fig. 36—39. Horny tissue of the horse's hoof.

— 36. A perpendicular slice from the upper part of the posterior wall of the hoof. Magnified 15 diameters.

a. A part of the crown edge (Krohnrinne, G.) of the hoof.

b. Several vascular cones.

c. Colourless, glassy horn.

d. Ducts of sebaceous glands, running between the cones for the bloodvessels.

e. The spirally twisted or corkscrew-like expansions of these ducts. The turns all go to the right like the threads of a common male screw.

f. The narrower part of the sebaceous duct in the firm horn, as it traverses the entire length of the horny crust of the hinder part of the hoof to open finally upon the plantar aspect of the bearing edge.

Fig. 37. A perpendicular slice of the lower part of the anterior wall of a horse's hoof. Magnified 40 diameters.

a a. Two twisted sebaceous canals, filled with brown sebaceous matter.

b b b. Smaller pigmentary spots which surround the canals.

c c c. Larger pigmentary spots, surrounding a middle one composed of smaller streaks.

Fig. 38. A horizontal transverse slice of the wall of the same hoof, cut from near the bearing edge; magnified 40 diameters.

a a a. The inferior ends of the spirally twisted sebaceous canals.

+ +. Their external openings. The other references as in Fig. 37.

Fig. 39. A thinner slice of the same hoof from the same situation, magnified 80 diameters.

The spiral canals here form but a quarter of a turn. The pigmentary spots appear as translucent, elongated, pigmentary granules.

a. Sebaceous canals.

b. Tubular shaped smaller pigmentary granules disposed around these.

c. Larger pigmentary granules, enclosing the smaller ones.

d. Pigmentary granules, beyond the pigmentary tubuli.

Fig. 40. Section of the integument of the palm of the human hand.

a. Corium, or cutis vera—true skin.

b. More compact stratum of this upon which

c d. The papillæ, or papillary body—the vasculo-nervous cones—are seated.

c. Nearest rank of tactile papillæ.

d. Next rank in order of the same.

e. Horny epidermis or cuticle, composed of numerous superimposed sinuous layers of horny squamæ.

f. The sinuous projections of the epidermis, formed by the most external of the horny layers of which the tissue consists.

g h i. The spirally twisted excretory ducts of the sebaceous glands.

g. In the corion.

h. In the cuticle.

i. Their external openings.

Fig. 41. Horny epithelium, from the conjunctiva covering the cornea of the eye, as a continuation of the general tegumentary cuticle, magnified 150 diameters (horse.)

a. Single scales.

b. Simple lamina of the epithelium.

c. Double lamina of the same.

Fig. 42. A hair with its associated sebaceous glands, from the vicinity of the crown of the hoof, magnified about 25 diameters (horse.)

a a. Corium.

b. Horny cuticle.

b. Malpighian pigmentary layer.

c c c. Hair follicles, hair-sheaths.

c. Their funnel-shaped outer openings.

d d. Excretory ducts of the sebaceous glands.

e e. Secreting pulp of the hair and its sheath.

f f. Part of the pulp which immediately secretes the root of the hair.

g. Thickening of the still clear portion of the root of the hair.

h. Root of the hair.

i. Its cavity filled with vessels, nerves, and cellular substance.

k l m. The hairs, prolongations of the roots.

n n. The mulberry-like sebaceous glands.

o. Union of the pediculated vesicles of the gland to form the excretory duct.

p. External surface of the vesicles.

Fig. 43. Sebaceous and sudoriparous glands (prepuce of the stallion) magnified about 12 diameters.

a a. Epidermis.

b. Infundibuliform depression of the same.

c c. Sheaths of hairs.

d d. Pulps of hairs in their sheaths.

e e. Sebaceous glands.

f f. Their excretory ducts.

g. Root of hair.

h. Delicate hair.

i. Sudoriparous glands.

k. Their excretory ducts.

Fig. 44. Section of the integument of the scrotum, magnified 8 diameters (horse.)

a a. The globular cutaneous papillæ, covered with the dark coloured cuticle.

b b. Infundibuliform inversion of the cuticle.

c. Excretory duct of a sebaceous gland.

d. The particular ducts of the several glomeruli composing the gland.

e. The sebaceous gland, filled with brown coloured secretion.

Fig. 45. Section of the labium, magnified about 8 times (mare.)

a. The papillæ covered with cuticle.

b. The infundibuliform inversion of the cuticle.

c. The excretory ducts of the sebaceous glands.

d. The secondary divisions of these.

e. The appendices or vesicles of the sebaceous glands, filled with sebaceous matter.

f. Fine hairs.

Fig. 46—48. Epithelial corpuscles and ciliary corpuscles.

— 46. Section of the mucous membrane of the trachea, magnified 100 diameters (horse.)

a b c. The ciliary epithelium.

a. The ciliary corpuscles.

b. Ciliæ attached to the crown of the same.

c. Thick superficies of the mucous membrane, formed of elastic membrane, upon which the ciliary corpuscles, and ciliary cellular fibrils, are implanted by means of their pedicles.

d. Single detached ciliary epithelial corpuscles magnified 125 times. Among these are to be distinguished cylinder or roller-shaped ciliary corpuscles, bell-shaped corpuscles, cup-shaped corpuscles, and bicellular corpuscles, the latter with pedicles at either extremity.

Fig. 47. Villi of the conjunctiva, from the inner aspect of the upper eye-lid (horse.)

a a. Two villi.

b b. Spaces betwixt these.

c. The cells of the cellular epithelium, or the coronary edges of the epithelial corpuscles.

d. The nuclei of the corpuscles.

Fig 48. Ciliary corpuscles and their constituent parts.

A. A bell-shaped ciliary corpuscle seen from the side, and magnified about 400 diameters.

a. The ciliary crown.

b. The ciliary papilla.

c. The coronal pit.

d. The ciliæ.

e. The coronal globule (coronal nucleus.)

f. The body.

g. The nucleus.

h. The pedicle by which the corpuscle is attached to the mucous membrane.

B. A ciliary corpuscle viewed from the coronal aspect.

a a. The ciliary corona.

b. Papillæ.

c. Coronal depression.

d. Section of the ciliary processes (ciliæ.)

e. Globule.

C C. Globules that have been detached, and have fallen out, lying in the midst of

D. Extremely minute mucus-granules.

Fig. 49. The most delicate cellular membrane and elastic fibres, magnified 150 diameters.

A. Compact serous membrane, formed of a simple lamina of sinuous fibrils of cellular tissue lying parallel to one another.

B. Cellular membranous tissue of the finest transparent serous membrane.

C. The very delicate sinuous elastic filaments, composing the elastic tissue in the fibrous tunic of the smallest bronchial ramifications (horse.)

Fig. 50. A portion of the great omentum, to show the reticulate structure of the serous membrane in this part, magnified 150 diameters. The membrane consists of an interlacement of

a. Cellular membranous fasciculi or ropes, and

b. Of cellular membranous filaments.

Fig. 51. Sinew, tendon,—sinewy tissue, magnified 150 diameters.

a. Connection of sinew with muscle.

1. Delicate sinewy fibrils, which are united with the conical shaped extremities of the primary muscular bundles, 2.

b. Sinuous tendinous bundle, or cord.

+. Lacerated and corrugated sinewy fibrils.

c. Tendinous bundle, shortened and lying in alternate loops.

Fig. 52. Bundle from a ligament (one of the lateral ligaments of the knee-joint) magnified 120 diameters (horse.)

Fig. 53. Cartilaginous tissue.

A. Fibro-cartilage, from an inter-articular cartilage of the knee-joint, magnified 120 diameters (horse.)

a. A layer of parallel fibres.

b. A layer of other fibres crossing the former at right angles.

B. Cellular-cartilage of the septum narium, magnified 200 diameters (horse.)

a. The rounded cartilage-cells scattered through the hyaline matter.

b. The compressed and elongated cartilage-cells in the vicinity of the mucous membrane.

Fig. 54—56. Elastic tissue.

— 54 Reticulate elastic tissue of the ligamentum nuchæ magnified 200 diameters (horse.)

a. Loosened elastic tissue with the meshes opened.

b, Elastic tissue in its natural condition, the meshes close.—Elastic tissue, its fibres disposed in lines and layers parallel to one another.

Fig. 55. Elastic tissue from the middle fibrous coat of the aorta, magnified 300 diameters. Elastic tissue, its fibres intertangled (ox.)

Fig. 56. Elastic tissue from the eye-ball of the ox, magnified 200 diameters.

1. From the ciliary ligament.

2. From the choroid coat in the vicinity of the ciliary ligament and in the iris.

Fig. 57—59. Cartilaginous tissue.

— 57 Cellular cartilage from the septum narium, magnified 560 diameters (horse.)

a. Hyaline cartilage,—vitreous cartilaginous matter.

b d. Cartilage-cells with granular nuclei.

b. Cell.

c. Nucleus.

d. Long-shaped cartilage-cell.

Fig. 58. Transverse section of a costal cartilage in the first stage of ossification, magnified 160 diameters (dog.)

A. Cells disposed in groups, uninclosed; at

a. They are imperfectly inclosed by an indistinctly limited area ; at

B. On the contrary, the cells, pressed together, are completely surrounded by a distinct area; as yet, however, there is no deposition of earthy matter apparent.

Fig. 59. Reticular cartilage from the arched portion of the concha of the ear, magnified 300 diameters (horse.)

a. The fibres of the intercellular net-work, corresponding to elastic tissue, and also of similar origin.

b. Cartilage cells—cartilage-corpuscles.

Fig. 60. Costal cartilage, the ossification begun, from the neighbourhood of the transverse slice represented in fig. 58, magnified 160 diameters.

1, 1. The reticular cells formed by the bony matter just deposited.

a. The osseous cartilage (hyaline substance.)

b. Osseous corpuscles (nuclei of the bone-cells.)

c. Fat-vesicles occupying the place of the cartilaginous substance which has been removed.

Fig. 61—70. Elementary parts of bone.

— 61 A perpendicular section from the middle of the femur, magnified 12 diameters (horse, 4 years old.)

a. Ossific cartilage, with scattered bone-corpuscles.

b. Canals—medullary, or for vessels.

c. Anastomoses, or communications of these with one another.

Fig. 62. A portion of the same section magnified 50 diameters.

a. Ossific cartilage, with included bone-corpuscles.

b. Medullary canals.

c. Transverse communicating branches of these.

Fig. 63. Transverse section from the humerus, magnified 15 diameters (young horse.)

a a a. Vascular canals running parallel with the medullary cavity.

b b. Perpendicular medullary canaliculi, transversely divided.

c. Anastomotic vessels betwixt the perpendicular and transverse vessels of the bone in medullary canals.

Fig. 64. A portion of the same section magnified 50 diameters.

a. Perpendicular canaliculi.

b. Transverse canaliculi.

c c. Branches of communication between them.

Fig. 65. A very small portion of the same section magnified 100 diameters.

a. Transversely arranged rank of osseous corpuscles.

b. to *c.* Osseous corpuscles arranged concentrically to the transversely divided medullary canaliculus *c.*

d. Transverse canaliculus.

Fig. 66. Section of the outer table of the human skull, magnified 15 diameters. The medullary canaliculi form a rete.

Fig. 67. Transverse section of the rubbing surface of a grinder from the upper jaw of the full-grown horse, magnified one-third.

a' a'. Bony substance of the outer aspect of the tooth.

a. The inner portion of the bony substance—cortical substance.

b. Vitreous substance, or enamel.

c. Ivory or substance of the tooth.

d. Brown middle streak of pigment.

e. Inner layer of the vitreous substance.

f. Inner layer of the bony substance.

g. Deep brown depression, not yet filled up by the inner bony substance.

Fig. 68. The portion of the tooth inclosed by the oblong *h.* in fig. 67 magnified 36 diameters.

a b. External bony or cortical substance.

a. External margin of the tooth.

b. Connection of the external bony substance, with the enamel. The surface of the bony substance which is united with the enamel is covered with hemispherical points (*b' b'*) which are sunk amidst the enamel and inclose bony corpuscles; these are the bony cells with their nuclei which penetrate the enamel.

b'. Connection of the internal bony substance with the internal enamel.

c c c. More compact layers of bony substance, in which the bony cells with their nuclei,—the bone-corpuscles, lie in compressed rows.

d. Bone-corpuscles.

e. Osseous canaliculi.

f g h h. External layer of enamel.

f h. The margin of the external deposit of enamel.

f. The suture or line of union between the substance of the tooth, or tubular substance, broken through, interrupted by the branched periphery of the tooth-tubulus *i.*

n. Crack in the vitreous substance—an effect of the drying of the tooth.

k k l. Substance—tubular substance of the tooth.

k. The bent tubuli branch, to pass over into the enamel at *i f g* and *n.*

l. Section of the central mass of the substance of the tooth.

m. Inner margin and inner suture.

b' m. Internal deposit of enamel.

b' o e' n. Internal bony substance.

e' e' e'. Vascular canals.

o and *n.* Bone-corpuscles.

Fig. 69. Cartilage in process of ossification, magnified 250 diameters.

A. Cartilage with regularly disseminated corpuscles, —cellular-cartilage.

B. The corpuscles, with the commencement of ossification are forced into groups, between which the hyaline cartilage is transformed to bone-cartilage.

C. The groups of cartilage-corpuscles are completely inclosed by bone-cartilage.

D. The cartilage-corpuscles are rendered less transparent by the process of resolution that is going on; at the same time the bone-corpuscles make their appearance in the bone-cartilage.

E. The cartilage-corpuscles are dissolved and partially removed.

F. The cartilage-corpuscles have disappeared; have been absorbed.

a. In spongy bones, cells filled with fat remain (Fig. 60, 1.)

b. In compact bones the cells are reduced to minute canals by the growth of the bony matter, or they disappear entirely.

Fig. 70. Bone-corpuscles magnified 450 diameters.

a a. The bone-corpuscles—nuclei of the bone-cells.

b. The vessels of the bony cells (canaliculi calicophori, Müller) which by their inosculations form a rete.

Fig. 71—73. Contractile tissue.

— 71. Contractile tissue of the corium, seen from the inner aspect, and magnified about 8 diameters (hog.)

a. The filaments of contractile tissue crossing each other, and surrounding

b. The roots of the bristles, which are covered with fat.*

c. The bristles seen arising in threes together.

d. Divided cæca or appendices of the sebaceous ducts.

e. Divided vessels and nerves.

f. Pigmentary deposits.

Fig. 72. A portion of integument from another part of the body of the same animal, magnified about 12 diameters.

a a. The interlacing filaments of the contractile tissue.

b. Fat cells of the roots of the bristles.

c. Bulbs of the bristles.

Fig. 73. Contractile tissue of the dartos, from under the common integument of the scrotum of the ram.

a. Strings of contractile tissue: strings composed of numerous simple filaments.

b. Single filaments of the same.

*Among several of the lower animals the contractile tissue may be seen in certain situations passing in threads from the root of one hair to another, by which the power is acquired of raising the bristles, mane, or hair on end.

c. Filaments of cellular tissue.

Fig. 74—86. Elementary parts of muscles.

— 74. Granular muscle of the *organic* life, from the muscular tunic of the uterus, magnified 80 diameters (cow.)

A. A primary bundle.

B. A bundle resolved into its several elements by means of alternately spirting water upon it, and gentle pressure between two plates of glass.

a. The filaments which serve as the basis of the tissue (filaments of cellular tissue and vessels.)

b. The attached muscular granules, in uninjured bundles, arranged in rows like strings of beads.

Fig. 75. Filamentous muscle of the *organic* life.

A. Primary bundles and ropes of filamentous organic muscle, magnified 80 diameters (longitudinal fibres of the colon, horse.)

a a a. Bundles.

b. A rope or string of muscular fibres teased out.

B. A bundle of sinuous primary fibres teased out.

C. Puckered or crisped primary muscular fibres.

D. A grating of rigid muscle of the *animal* life, (*a*. from the lingualis, *b*. from the myloglossus,) after the action of oil of turpentine. In these bundles neither transverse streaking nor longitudinal fibrillation is distinguishable.

Fig. 76 A. A grating of organic primary muscular filaments. A very thin slice from the muscular tunic of a piece of small intestine that had lain for a short time in brine (sheep.)

a. Longitudinal layer.

b. Transverse layer.

B. Two organic primary muscular bundles, intermediate betwixt the granular and filamentous structure, or compounded of the two (from one of the longitudinal muscular bands of the colon, horse.)

Fig. 77—86. Elements of the muscles of voluntary motion, or of the *animal* life.

Fig. 77. Simple layer of a primary bundle of a muscle of voluntary motion (long head of the *triceps brachialis*, horse.)

Fig. 78. A primary muscular bundle, magnified 200 diameters (same animal.)

a. Primary bundle with wrinkled boundary line and complete striæ.

b. Primary bundle with the sheath removed in parts, or in which the granules of the primary filaments in some places only appear transversely arranged in rows near to one another; in other places they appear co-ordinated lengthwise, rather than transversely, so that in these the bundles seem to be streaked longitudinally.

c. Primary bundle with the sheath torn longitudinally, or with an interruption of the transverse striæ in the direction of the long axis.

Fig. 79. Primary bundle of a muscle of voluntary motion, magnified 200 diameters.

1. Bundle which has been stripped off from a larger mass of muscle.

a. Transverse striæ, or transversely streaked sheath.

b. Sharp torn edge of the same.

c. Primary filaments, presenting the appearance of a series of adhering hemispheres.

2, 3, 4. Primary bundles of a voluntary muscle as I have occasionally observed them when they were examined in the recent state.

2, *a*. Primary fibres.

b b b. Spiral sheath of flat filaments.

3, *a*. Primary fibres.

b. The spirally convoluted flat filaments, united five or six together, form broader spiral bands.

4, *a*. Primary fibres, which at

b. Are lacerated.

c. Spiral sheath composed of several flat filaments connected together.

d. Lacerated spiral filaments.

Fig. 80. Primary muscular bundles, the sheaths having been burst by the compressor (rabbit.) *

a a. Two compressed layers of primary fasciculi, from which the longitudinally streaked bundles *b*, that scarcely show any trace of transverse streaking, have been squeezed out.

c c. Isolated bundles.

d. A part where the fasciculi are still connected and included in their sheaths.

Fig. 81. Three portions of primary bundles of voluntary muscles (horse) magnified 200 diameters.

1. A bundle, with nipple-shaped torn extremities, which is only partially occupied with transverse striæ.

2. A fasciculus without transverse striæ, the primary filaments slightly sinuous, and the torn extremities conical.

3. A bundle with notched torn extremities, without particular transverse striæ, but with broad darker transverse bands, as if depending upon some partial separation of the primary filaments.

Fig. 82. Two short pieces of primary fasciculi of voluntary muscles magnified 300 diameters; also three primary filaments of the same pieces magnified 700 diameters (horse.)

A. A piece at one end of which the moniliform primary filaments are seen forming a kind of tuft. The diameter of the component globules is greater in the direction of the length of the filaments than of their breadth; the filaments and the fasciculi therefore appear elongated. As in this passive state, or state of relaxation, the primary filaments tend to part from one another, the bundle they compose appears longitudinally streaked.

B. A portion of a muscular bundle in the moment of active contraction. Here the transverse diameter of the globules increases at the expense of the long diameter: and

* Although I do not maintain that the transverse striæ of the muscles of animal life depend on the presence of a wrinkled sheath, still I am by no means satisfied that a sheath of this description does not exist.

thus and because the globules approximate more closely and stand in regular transversely arranged ranks, the fasciculus appears shortened, transversely streaked, and increased in diameter.

C 1. A primary fibre in a state of relaxation.

2. A primary fibre in a state of contraction.

3. A primary fibre, which, as often happens, appears shortly sinuous, or even twisted like a cord, rather than composed of globules connected with one another in rows.

Fig. 83. Structures met with in the voluntary muscles, whose office, and relations to the surrounding tissues, are not yet known, magnified 150 diameters.

3, 3. Two primary muscular fasciculi from the masseter muscle of the horse.

1, 2. Two other fasciculi lying near to these and parallel with them, filled apparently with convoluted filaments, the sheaths, which between *b* and *b* were accidentally injured.

a a. Gelatinous external covering.

b b. A part where this has been accidentally removed.

c. A finer inner envelope, which having escaped injury still surrounds the fasciculus 1, completely. The corresponding fine membrane having been lacerated in fasciculus 2, its contents have escaped.

d. The convoluted fibres or filaments, of which from eight to ten are contained in each fasciculus, protruding from their sheath.*

Fig. 84. Primary muscular fasciculus, from the heart (dog.)

a a. Fasciculi which divide into two.

b b. Parts of fasciculi transversely streaked.

Fig. 85. Muscular fasciculi from the bladder (dog.)

— 86. Muscular tissue from the tongue (hog.)

* I have found enigmatical fasciculi of the same description, although less distinctly, in the lips and tongue of the full-grown horse. I have not met with them elsewhere.

a a. Fasciculi of the myloglossus muscle, which terminate in cones under the mucous membrane of the tongue.

b b. Fasciculi of the lingualis cut transversely across, as they threaded the primary fasciculi of the myloglossus nearly at right angles.

Fig. 87. Pediculated vorticellæ * very highly magnified.

A. B. C. D. Four vorticellæ in different conditions, each being assumed voluntarily.

A. With the pedicle fully stretched out, and the cup or bell open.

a. The bell-shaped body, through which shines the polycystic stomach.

b. The crown.

c. The ciliæ.

1. A very delicate muscular fibre, wound around the erectile vessel, and in the relaxed state.

2. The erectile vessel distended with fluid from the body, by which the pedicle is extended.

B. A vorticella moving hither and thither, the pedicle slightly sinuous.

3, 3. The granules in the water thrown into circular motion or whirlpools by the action of the ciliæ of the animals.

C. A vorticella closed, and the pedicle spirally retracted by the action of the muscle, which, in the opposite state of the pedicle, is wound about the erectile vessel. Here the vessel (2.) appears everywhere external; the muscle (1.) again is internal. The ciliæ are concealed within the closed cavity of the body.

* These figures are introduced here: 1st. From the singular resemblance which vorticellæ bear to the ciliary corpuscles (vide fig. 48;) 2nd, Because infusory animalcules are encountered in the living bodies of animals, particularly in morbid deposits; 3rd, Because their pedicle is composed according to my observations of the simplest muscular tissue and erectile vessel.

D. A vorticella which, after having been closed, is expanding the body and erecting the pedicle. *

a. The body now of a globular form.

b. The half expanded crown.

1. The muscle.

2. The erectile vessel.

E. An agglomeration of granules to which the pedicles are attached.

Fig. 88—90. Constituent elements of nerves.

— 88. 1, 2. Two primary fibrils of a spinal nerve examined in the body of an animal just dead.

a. The investing membrane pinched in at intervals. In the living animal the fibrils are perfectly cylindrical.

b. The still transparent fluid contents.

3. A nervous fibril examined some short time after the death of the animal, immediately before the consolidation of the contents. The fibril is more irregularly sinuous.

4. A primary nervous fibril more highly magnified.

a. Nervous tunic (nervous tubulus.)

a'. Presumed ciliary epithelium.

b. The cone-shaped ciliæ.

5. The ciliæ more highly magnified.

6. Highly magnified primary nervous fibril.

a. Tubulus.

b. The consolidated contents.

7. A delicate nervous fasciculus in its sheath.

a. The sinuously disposed fasciculus.

b. The cylindrical sheath.

8. A nervous fasciculus, the sheath of which exhibits sinuosities also.

a. The fasciculus.

b. The sheath.

9. A delicate nervous cord highly magnified, consisting of four primary fibrils; the particular sheaths of the several fibrils are conspicuous.

* In this process the body of course makes as many revolutions upon its axis as the muscle of the pedicle is twisted times around the erectile vessel.

10. A cylindrical nervous fasciculus.

11. Sections of nerves.

a. Section of a cylindrical nervous fasciculus.

b. Section of a nervous cord consisting of a single layer of fasciculi.

c. Section of a cord made up of three layers.

d. Section of a pyriform fasciculus.

Fig. 89. Minuter elements of the nervous system.

1. Cerebral medullary granules or globules.

2—6. Ganglionic cells, globules or corpuscles.

2. An egg-shaped ganglionic globule.

a. The nucleus.

b. The nucleolus.

3. A ganglionic cell, nearly globular.

a. The nucleus.

b. The nucleolus.

4. A pear-shaped ganglionic globule.

5. Two ganglionic cells with their sheaths and bond of connexion (cellular tissue.)

a. The bond of connexion.

a' a'. The sheaths of the cells.

b. The ganglionic corpuscles.

6. A ganglionic cell, surrounded by its filamentous sheath.

7. Root of a cerebral nerve.

a. The nervous roots, connected with which are numerous medullary globules, approaching each other.

8. Root of a spinal nerve.

a b. The portion of the root which lies within the spinal cord.

a c. The root after it has passed from the spinal cord.

c. Point at which the root passes through the dura mater of the cord.

c—8. The root beyond the sheath of the cord.

Fig. 90. Final expansions in the dermis, of nerves of sensation. Peripheral nervous plexuses (with or without ganglionic cells ?) (hog.)

1. Simple plexiform expansion of a nervous cord.

a. The nervous cord.

b. The cord resolved by the separation of its component fibrils.

c. Fibrils spreading widely from the rest.

d. Part from which primary fibrils depart, and where others from neighbouring fasciculi are received.

f. A new cord formed by the reassembled nervous fibrils.

2. Two nervous plexuses or expansions from the same cord.

a. The nervous fasciculus.

b b. The two plexiform expansions proceeding from it.

c. Single fibrils.

d. Plexus formed by fibrils proceeding from and fibrils approaching the great plexus.

e. A terminal loop.

Fig. 91—102. Peripheral distribution of nerves of voluntary motion, and of common sensation.

Fig. 91. A portion of the transversus abdominis muscle with the inosculations and loopings of several muscular branches of nerves (rabbit.)

a a a. Primary fasciculi of the muscle.

b b b. Three terminal branches of muscular nerves.

c. Division of one of these branches into ramusculi, each consisting of four or five primary fibrils.

d. Most delicate twigs consisting of no more than two primary fibrils, and continuations of these into

e e e e. Twigs consisting of single primary fibrils forming terminal loopings.

f f f. Terminal loops which pass over into other nervous twigs betwixt the muscular fasciculi.

g. Two associated primary fibrils, one of which, after joining the middle nervous cord *b*', soon quits this in company with another primary fibril, and enters deeply among the muscular fasciculi at *h;* whilst the other, after running for some way by the side of a terminal loop at *i i*, parts company with it, runs isolatedly at *k*, then joins two primary fibrils of the right hand cord at *l*, is associated at *m* with one of these only, separating from which, it finally forms the terminal loop *n*, and is re-associated with the middle cord *b*'.

Fig. 92—101. Peripheral relations and mode of distribution of the nerves of sensation.

Fig. 92. A thin perpendicular slice from the integument of the lip, dried and steeped in oil of turpentine (hog.)

a a a. Fine cords and fasciculi of the labial branches of the nervus trigeminus.

b b b. Simple nervous fibrils, which, without forming proper loops, pass from one fasciculus to another.

c c c. Terminal loops within the substance of the dermis.

d d d. Terminal loops reaching near to the surface.

e. Tactile convoluted terminal loops, forming the papillæ or papillary bodies of the skin.

f. A larger tactile papilla formed of the convoluted terminal loops of several cords.

g g. The external surface of the dermis in contact with the epidermis.

Fig. 93. The tactile nerves of the extremity of the human thumb.

a a a. Three terminal cords of the nervus volaris pollicis of the median nerve.

b b. Simple primary fibrils in the terminal plexus within the skin.

c c c. Simple bows or knots of terminal loopings between the papillæ.

d d d. Three papillæ, the nervous fibrils entering into their constitution convoluted and in the fashion of rosettes.*

* In injected preparations the arteries present very nearly the same appearance, so that I have often found it requisite to look narrowly with a view to distinguish whether I had nerves or arteries before me.

Fig. 94. Section of a portion of the integument of the neck (hog.)

a a. Outer surface of the skin, darkened by a fine pigmentary deposit.

b. Depression where a bristle issues, and the ducts of sebaceous and sudoriparous glands terminate.

c c c c. Cutaneous nervous cords.

e e. Nerves of the secreting pulps of bristles.

d d. Loops of nervous fasciculi.

e. Terminal plexus under the cuticle.

f. A cord resolved into fibrils (perhaps a peripheral ganglion, of which many are encountered in the skin*) vide fig. 90.

g g g. Anastomotic fibrils—fibrils passing from one fasciculus to another.

h h. Terminal loops that surround the bristles.

i. Duct of a sebaceous gland.

k. Expansion in the course of the same where a secreting crypt has been cut away.

l. Union of the sebaceous follicle with the sheath of the bristle.

m. Sebaceous follicle,—simple sebaceous crypt.

n. Duct of a sudoriparous gland.

o o. Portions of the secreting follicles of two bristles.

p. Cavities of the same.

q q. Sections of the roots of the two bristles.

r. Bristle.

s. Fat in the nidus of the bristles.

Fig. 95. Peripheral plexiform distribution of the nerves in a portion of the skin of the neck, seen from the outer or epidermic aspect (hog.)

a a a. Nervous twigs and terminal fasciculi, which traverse the skin slantingly and form the terminal plexus.

b b b. Meshes of the terminal plexuses.

* I must say, however, that I have never seen ganglionic globules in these plexuses.

c c c. Triangular spaces betwixt the meshes.

Fig. 96—101. Different forms of the peripheral terminations of nerves of sensation (nerves of touch.)

Fig. 96. Simple terminal loops of cutaneous nerves seen from the surface of the skin.

Fig. 97. Simple terminal loops of nerves of the skin, each of which is formed of the final branches of different fasciculi.

Fig. 98. Four simple tactile loops, three of which are formed by two different fasciculi, whilst the fourth, (that to the right hand) is formed from one fasciculus only.

Fig. 99. A convoluted nervous or tactile papilla, formed of two, or more properly of only one terminal fibril returning on itself.

Fig. 100. A fusiform tactile papilla from the lip of the horse. A primary nervous fibril by several turns or convolutions, forms a spindle-shaped knot, and then proceeds onwards in the same direction.

Fig. 101. A rosette-like compound tactile nervous papilla seen from the surface. Several slightly convoluted terminal loops lying in the same plane form concentric circles, in the centre of which a larger hemispherical convoluted papilla like that represented in fig. 99, stands somewhat raised above the general level.

Fig. 102. Soft nervous envelope.

a. A portion of a nervous fasciculus.

b. A small blood-vessel accompanying the same, filled with blood-corpuscles.

c c. The delicate sheath or envelope of the nervous fasciculus consisting of cellular fibres.

d. An isolated portion of one of these cellular fibres, more highly magnified to show the granular nucleus.

Fig. 103. A piece of the allantois seen from the external surface (sheep.)

a a. A blood-vessel containing a number of altered blood-globules, over and in the vicinity of which the cellulo-membranous sheath, freed from its epithelial endusium, is so separated, that its component fibres with their cells and nuclei are distinctly to be seen.

b b b. Superficial rete of epithelial cells under which the allantoic membrane composed in the manner just stated extends. The nuclei of the epithelial cells are only inserted in a part of the figure to the left. Each cell, however, is to be understood as having had its nucleus.

c. Altered blood-globules.

d d. A few of the cellulo-membranous fibres which formed the outer sheath of the vessel. These run parallel with its axis, and present the same appearance as those which form the outer sheath of the finer nervous fasciculi and cords (vide fig. 102, *c c*.)

Fig. 104. Is a half plan figure to show the way in which the finer nervous fasciculi mutually interchange the most delicate fasciculi and primary fibrils. The cord *a* unites at *c* with a portion of the cord *b*, and gives delicate fasciculi and a simple fibril to the cord *d d* proceeding from *b*. (Valentin.)

Fig. 105. Tuft of terminal loops of the nerve of sensation from the pulp of a grinding tooth of the sheep. (Valentin, On the course and terminations of the Nerves, fig. 31.)

a a. Nervous cords.

b. Single nervous fibrils.

c. Terminal loopings of these.

d. Terminal loopings of the cords *a a*.

Fig. 106. Plexus of a nerve of sensation in the skin, (hog.)

a. Delicate nervous cord.

b b. Simple nervous fibrils.

c. Transverse and longitudinal sections, generally of fibres of the cellular membrane which accompany the ultimate divisions of the nervous filaments, occasionally of the nervous filaments themselves.

These delicate fibrils compose an independent rete within the meshes of the nervous plexus.

Fig. 107. The second dorsal ganglion of the sympathetic

nerve very highly magnified (mouse.) (Valentin, op. cit. fig. 44.

a b. Anterior and posterior cord of the sympathetic nerve, which connect the first and the third dorsal ganglia with this the middle one.

c c c c. Delicate cordlets which pass either to the viscera or to join the second dorsal nerve.

d. Ganglionic globules or cells.

e. Nervous fibrils coursing round the ganglion.

Fig. 108—113. Lymphatic vessels.

— 108. Lymphatic vessels and lymphatic glands from the spermatic cord of the horse, magnified 8 diameters.

A. A. The lymphatic glands.

a a a. Peripheral, efferent larger lymphatic vessels.

b b. An efferent or central lymphatic vessel.

c c'. Superficial network of delicate lymphatics, which serves in part to connect the small flat gland *d* with the efferent vessel *b.*

d. A very small, loose, semiglandular plexus of lymphatic vessels.

e. Extensive lymphatic network, formed of the vessels of the gland and the parts immediately adjacent.

f. Larger lymphatic vessels passing over and near to the gland, the numerous valves of which are obvious.

g. Delicate efferent lymphatics.

Fig. 109. The inferior cervical lymphatic gland of the horse, of the natural size.

a. The inferior portion of the connecting vessel of the cervical gland—the *tracheal canal* of Gurlt.

b. Larger trilobular } cervical gland, the vessels of
c. Smaller inferior } which are imperfectly injected.

Fig. 110—112. Transit of lymphatics into veins, magnified 1 diameter.

Fig. 110. Termination of a large lymphatic vessel in a vein from the iliac mesentery of the horse.

a. The lymphatic vessel, which was proceeding back towards the intestine from a mesenteric gland (an anastomotic vessel between the lymphatic and proper venous systems.)

b. Two semilunar valves at the point of communication, extremely like the ileo-cœcal valve of the human subject in structure.

c. A mesenteric vein.

Fig. 111. A piece of a mesenteric vein laid open, in which lymphatics are ending (to save space, two of these are represented close together.)

a. Mesenteric vein.

b. Lymphatic vessel.

c. The common cavity of the two semilunar valves represented as shut or in contact.

d. The free edges of the valves.

e. End of the lymphatic within the vein.

f g h. Opening of a lymphatic within a vein, the valves open.

f. The valvular pit or depression—the space between the valves and parietes of the vessel.

g. The free edge of one of the valves.

h. The cavity of the lymphatic vessel.*

Fig. 112. A more complete valve between a lymphatic and a vein (after A. Meckel, in Meckel's Archiv. 1828.)

a. A piece of a mesenteric vein of the horse seen from within.

b. A lymphatic vessel approaching the vein *a.*

c. The continuation of the lymphatic within the vein, by which a peculiar valve is formed, a structure, however, which is also encountered between vein and vein (vide fig. 114 and 116.)

d d. Two opposed semilunar valves, lying in contact with the parietes of the vein.

* The valve that guards the orifice of the thoracic duct where it enters the axillary vein is precisely of the kind here figured. So is the ilio-cœlic valve of the human intestine, and the valves of the veins in general (vide figs. 116 and 117.)

e. The orifice of the lymphatic vessel within the vein.

Fig. 113. Mode of origin of a lymphatic or lacteal vessel at the extremity and within the substance of an intestinal villus, from the human subject, 16 years of age, after Krause in Müller's Archiv. 1837, Fol. 1.

The delicate incipient vessels, which in all probability are not completely distended, proceed here immediately, and then after they have formed a simple rete by anastomosing together, into the central vessel. It is probable that the lacteals have generally the same peripheral distribution as the veins, that they commence at every point in festoons and delicate reticulations.

Fig. 114—120. Structure of veins.

— 114—116. One half of a vein from the neck of the horse slit longitudinally in two, of the natural size, but somewhat shortened in the drawing, so that the valves are brought closer together than they are in nature.

Fig. 114. The vessel with the valves open, and the cavity free, as they are when the blood is flowing regularly towards the heart, or when the pressure in the branches is greater than it is in the trunk.

a. Superior, and

b. Inferior divided extremity of the vein.

c. Branch entering the larger vein laterally.

d. The valve guarding the entrant orifice of this branch, open.

e. The valve guarding the entrant orifice of a branch entering the larger vein from behind—the valve open.

f f. Two bisected semilunar valves of the venous trunk, in contact with the inner parietes of the vessel.

g. An uninjured semilunar valve, applied to the inner wall of the trunk which it guards.

h. The outer coats of the vein.

i. The inner serous tunic which forms the valves.

Fig. 115. The upper portion of fig. 114, seen from below.

a. The vaulted external aspect.

b. The external membranous tunic of the vein.

c. The internal serous tunic.

d. The valvular pit between the vein and the valve.

e. The free edge of one of the valves.

Fig. 116. A perpendicular section of the same venous trunk, the valves represented as closed.

a. The upper end of the portion of vein represented.

b. The under end of the same.

c. Orifice of a lateral entrant branch.

d. Perpendicular section of the valve which guards it, closed.

e. The closed valve of the branch which enters from behind.

f f. Section of the two semilunar valves of the venous trunk raised from the internal walls of the vessel, or closed.

g. The untouched semilunar valve of the trunk, placed at right angles to the pair of valves *f f* raised, or closed.

The arrows by the side of figs. 114 and 115, show the current of the blood in reference to the action of the valves.

Fig. 117. The valves *f f* of fig. 116 seen from below.

a. The outer circle of the vein.

b. The external tunic.

c. The internal serous tunic.

d. The bulging or cavity of one of the semilunar valves.

Fig. 118—120. Erectile veins from organs susceptible of erection.

Fig. 118. Commencement of the vein of the dorsum of the penis, one half the natural size. The anastomotic branches are in contact by their sides, but they all proceed in the direction of the trunk, towards which they are tending (horse.)

Fig. 119. A convoluted venous mass of the natural size from the under side of the bulbus urethræ (dog.)

The several veins, without dividing into branches here, form transversely convoluted masses, which are not unlike the convolutions of the small intestines, or of the brain.

Fig. 120. Erectile venous mass from the human spleen, magnified one-half. The preparation made by corrosion.

a. A vein.

b. Rounded vesicular venous cavities.

c. Pyriform and apparently blind vesicles forming the beginning of the vein. Many branches and pedicles of vesicles are broken off.

Fig. 121—152. Structure of arteries.

— 121. A wax model of the three semilunar valves at the root of the aorta—reduced one-third in size (colt.)

a. Aorta beyond the valves.

b b b. Sides of the aorta vaulted outwards in the situation of the three valves.

c. Notch where the valve is attached to the aorta.

d. Imprint of the sacculus of the valve.

f. Sulcus where the free edges of the two neighbouring valves come into contact when they are closed.

e. Situation or impression of the three corpora Arantii, lying in the axis of the aorta, the valves being closed.

Fig. 122—135. Peripheral or terminal arborizations of the arteries.

Fig. 122. Bifurcate or dichotomous terminal subdivision of an arterial twig, where the last divisions of the proper arteries pass into the capillary arches, or retia, and the incipient branches of the veins.

Fig. 123. Polychotomous or pecteniform terminal subdivisions of an arterial twig.

Fig. 124. and 125. Penicillate terminal sub-divisions of arterial twigs.

Fig. 126. Pomoid or globular terminal sub-division.

— 127. Asteroid terminal sub-division.

— 128. Capituloid terminal sub-division.

— 129. Penniform terminal sub-division.

— 130. Palmiform terminal sub-division.

Fig. 131—134. Peripheral transition loops or festoons,—arterial capillary festoons.

Fig. 131. The most simple form of this mode of termination.

Fig. 132. A more complex form of the same mode of termination.

Fig. 133. Another and yet more complex form of the same mode of termination.

Fig. 134. Apparent terminal loops or nooses, each minute twig returning into itself.

Fig. 135. Tassel-like terminations of an artery (from the fœtal placenta of the horse.)

Fig. 136. The vessels of two intestinal villi, magnified 160 diameters (colon of the horse.)

a. A delicate arterial twig of the intestinal tunics.

b b b. Bifurcate subdivisions of the same at the bases of villi.

c c c. Distribution of the finest arterial twigs at the edges of the villi. They form a delicate rete in the villi with the vein which courses along the centre of each villus. The veins of the two villi represented are seen united in the common branch *d.*

Fig. 137—152. Peripheral relations of the blood-vessels of different tissues of the human body, after Berres's microscopical observations. The same forms are shown by my preparations to occur among the mammalia.

Fig. 137. The simple arterial loop or noose. This distribution is particularly met with at the points of the fingers and toes, under the nails, on the Schneiderian membrane, on the surface of the tongue, and in the mucous membrane of the mouth.

Fig. 138. Palm-formed arterial distribution, common in mucous membranes. From the tongue of a young subject.

Fig. 139. Complex, fasciculate and anastomatic distribution. Tongue of a child.

Fig. 140. The vascular rete of the salivary glands, which lies over the arborescent arterial plexus of these organs,

and forms the intermediate vascular net-work of their two orders of vessels.

Fig. 141. The rectangular linear arterial plexus from the muscular coat of the small intestine of a child. Lieberkühn.

Fig. 142. The comb-like linear arterial plexus of the muscles of animal life. From a child. Berres.

Fig. 143. The linear arterial erectile plexus. Iris of a child. Berres.

Fig. 144. The mesentery (of a frog?) with the arcuate dendritic vascular plexus. Berres.

Fig. 145. The membrana Ruyschiana of the eye of a new-born child with the simple vascular rete. Berres.

Fig. 146. The enveloping vascular retia of the nuclei of the thyroid body of a new-born child. Berres.

Fig. 147. The festooned vascular rete of the mucous membrane of the colon of an adult. Berres.

Fig. 148. The pulmonary cells with the vascular plexus. Barth.

Fig. 149. The deep lying twigs of the arborescent excentric arterial retia. Berres.

Fig. 150. The membrana Ruyschiana of the eye of a new-born child, with the simple vascular rete. Berres.

Fig. 151. The clubbed pampiniform arterial plexus, with its intermediate vascular rete, from the supra-renal capsule of a child. Berres.

Fig. 152. The intermediate loops of the asteriform arterial rete of the renal granules. Berres.

Fig. 153 and 154. Malpighian bodies of the kidneys.

— 153. To the left. The first division and sub-division of excentric asteroid arterial plexus of the renal granules (acini.) Barth.

To the right. The entire renal granule (acinus) together with the origins of the tubuli uriniferi and of the renal veins. Barth.

Fig. 154. The imperfectly conical lappets formed by the several cortical uriniferous tubuli, with the blood-vessels

and glomeruli injected: from the kidney of an adult, after Krause in Müller's Archiv. 1837, Taf. I. fig. 3.

Fig. 155. Imperfectly filled arteriæ helicinæ—convoluted or tendril-like arteries, from the penis of the human subject, after Müller, in Archiv. 1838, Taf. V.

Fig. 156—161. Structure of glands.

— 156. Beginning of the excretory duct of a salivary gland (the parotid of a foal one year old.)

Fig. 157. One of the tufts of the above more highly magnified.

a a. Salivary vessel (a branch of the excretory duct.)

b b. The pediculated secretory vesicles—the peripheral blind extremities of the excretory duct.

c c. Twigs of blood-vessels.

Fig. 158. Two entire, and portions of two other Meibomian glands seen from the inside of the eyelid (fœtal calf of 5 months.)

a. The excretory duct.

b. The orifice of this on the inner aspect of the edge of the eye-lid.

c. The secreting vesiculi.

Fig. 159. Pulmonary vesicles (horse.)

a. One of the most delicate bronchial twigs.

b. The pulmonary vesicles.

Fig. 160 and 161. Bilocular sebaceous glands (skin of the sow.)

Fig. 160. A globular, closely convoluted sebaceous gland.

Fig. 161. The same with its convolutions unfolded.

— 162. Nervi nervorum, particular primary nervous festoons of the nervous fasciculi (addition to the structure of nerves.)

a a. A delicate nervous fasciculus, highly magnified.

b b. A primary fibril which at *c.* forms a somewhat sinuous terminal loop, and at *d.* plunges in between two of the constituent primary fibrils.

e f g. A terminal loop which turns round more abruptly.

h. A third terminal fibril, whose course is indicated by the letters *k*, *l*, *m*, *n*.

Fig. 163. A delicate soft fasciculus of the sympathetic.

a a a a. Four primary fibrils, separated by delicate fibres of the general investing sheath.

b b. Two primary fibrils lying deeper, and scarcely to be distinguished.

c c c. Delicate cellular fibrils between the nervous fibrils.

d d. Stronger investing cellular fibres.

e e. Still stronger and more condensed external sheath of cellular fibrils (perhaps tubuli of cellular tissue surrounding one another concentrically.)

Fig. 164—238. Figures having reference to the Terminology.

A. Drops in their various relations to the bodies with which they are in contact and the magnifying power.

Fig. 164. Flat, spread out, round-shaped drop.

— 165. Flat, spread out, elliptical drop.

— 166. A spherical drop, the most remote point of which is in the focus of the magnifier or microscope.

Fig. 167. The same drop removed till its centre is in the focus of the magnifier.

Fig. 168. The same drop the upper point of which is now in the focus,—the nearest point of the surface of the drop is at focal distance from the magnifying power.

Fig. 169. Drops illuminated from the side and from above, in a less consistent medium.

B. Crystals.

Fig. 170. A flat or short four-sided pyramid, with truncated apex.

Fig. 171. A cubical cyrstal.

— 172. Rhomboidal tables.

— 173. Three-sided prism.

— 174. Six-sided prism.

— 175. A three-sided pyramid.

Fig. 176. Acicular crystals.

C. Grit, gravel, amorphous deposits.

Fig. 177. Globular gravel.
— 178. Granular gravel.
— 179. Mulberry-like gravel.

D. Flat formations.

Fig. 180. Six-sided } scale.
— 181. Eight-sided } scale.
— 182. Elliptical } scale.
— 183. Lamina, or lamella.
— 184. Flat fibre.
— 185. Squamous fibre.
— 186. Simple or unilamellar squamous membrane.

E. Granules, and granular formations.

Fig. 187. Granules.
— 188. Globules.
— 189. Granular band or fibre.
— 190. Granular corpuscle.
— 191. Granular fibrous bundle.
— 192. Granular membrane.

F. Nuclei, nucleoli, and round fibrous formations.

Fig. 193. Nucleoli in cells (*a.*) Nucleolus in nucleus (*b.*)
— 194. Cylindrical or round fibres, fibrils, filaments.
— 195. A bundle or fasciculus of fibres.
— 196. A fibrous cord (a smaller collection of fibres than a fasciculus.)

Fig. 197. A fibrous tissue.
— 198. A fibrous net or rete.
— 199. A fibrous grating.
— 200. A fibrous membrane.
— 201. A fibrous fascicular tissue.

G. Nuclei and nucleolated nuclei.

Fig. 202. A nucleus in an elongated rounded cell. *b.* Nucleus in a six-sided cell.

Fig. 203. Nuclear or nucleolar fibre.
— 204. Nucleolated nucleus in the cell.
— 205. 1. Blood-corpuscles or globules. *a* Nucleus (investment, envelope.) *b* Nucleolus (nucleus.)

2. Exudation-corpuscle or globule, previously to its transformation into a pus-globule.

3. Pus-globule or corpuscle.

Fig. 206. Exudation membrane.

— 207. Granular nucleus within a cell.

H. Vesicles and hollow fibres.

Fig. 208. Round and pediculated vesicles.

— 209. An acervulus, small cluster or heap of vesicles.

— 210. Hollow fibre (primary fibre of nerve.)

— 211. Hollow fibrous cord (most delicate nervous cord.)

Fig. 212. Hollow fibrous plexus (peripheral nervous plexus.)

Fig. 213. Hollow fibrous rete or net (capillary net or rete.)

I. Cellular formations.

Fig. 214. Nucleated cellular membrane, with intercellular rete.

a. A binucleated cell.

b. Uninucleated cells.

Fig. 215. Nucleated cellular membrane without intercellular rete.

a. Sectional line.

b. Row of nucleated cells.

c. Row of cells—cells whose nuclei contain nucleoli.

d. The cells divided in the line *a*, which in the section appear like a cellular fibre.

Fig. 216. Newly formed globular nucleated cells.

a. One of these isolated, with an excentric nucleus.

b. Nucleo-nucleated or incased cells of recent formation.

Fig. 217. Cartilaginous cells.

a. Elongated nucleated cell, with elongated nucleus.

b. Rounded nucleo-nucleated cell.

Fig. 218. Cells that tend to separate in lines, and formation of cellular fibres.

Fig. 219. Metamorphosis of cellular fibres into round threads.

a. Cellular fibres with granular nuclei and delicate produced connecting filaments.

b. Shrunk cells with connecting fibres.

c. Cell with three connecting fibres.

d. Cellular fibres with granular nuclei, which are connected by peculiar filaments that run through the intercellular fibres.

Fig. 220. Irregularly quadrilateral granular or granulated cell with three granular incased nuclei, two of which lie partly over one another. (A variety as regards the number and position of the nuclei.)

Fig. 221. Ciliary or ciliated cellular membrane.

a. Crown or circle of ciliæ.

b. Basis or roots of more distant ciliæ.

c. Nucleus of the ciliary cells.

d. The ciliæ.

Fig. 222. An isolated ciliary cell.

a. The cell.

b. The ciliary basis.

c. Ciliæ.

d. Nucleus.

Fig. 223. A four-celled ciliary cellular fibre.

a. Ciliary corona.

b. (above.) One of the granular nuclei, *b.* (below.) The cell connected with the membrane.

Fig. 224. Ciliary cellular fibres in connexion, and as they appear on the surface of a section of the ciliary fibrous membrane.

a. Uppermost nucleus (ciliary nucleus.)

b c. Rank of ciliæ.

Fig. 225. Formation of elastic tissue out of the intercellular rete.

a. Intercellular rete with included nucleated cells.

b. Transition into

c. Elastic tissue.

Fig. 226. Horn-cells in the fœtus, before their conversion into horn, still furnished with nuclei and nucleoli. (Valentin.)

Fig. 227 and 228. Change of the young cell into a scale, in section. In *a*—*e*, the nucleus is still recognizable. In *f*, the formed scale, it has disappeared.

K. Living animals in the living mammal now as constituent elements, and again as adventitious parasites.

Fig. 229 and 230. Cysticercus cellulosæ.

— 229. Cysticercus cellulosæ of the natural size.

a. Head.

b. Neck.

c. Caudal vesicle.

Fig. 230. Head, neck, and part of the body of the cysticercus highly magnified.

a. Point of the mouth.

b. The double circle of hooklets.

c c. Suctory papillæ.

d. Neck.

e. A part of the body.

Fig. 231—234. Seminal animalcules and seminal corpuscles from the epididymis (guinea-pig.)

Fig. 231. A seminal animalcule very highly magnified, seen from the abdominal aspect.

a a. The rounded margin of the flat spoon-shaped body.

b. Internal vesiculi (probably botryoidal stomach.)

c. Two globular organs (internal organs of generation? ovaries?)

d. Oral aperture on the oral papillæ.

e. Genital and anal orifice on the posterior papillæ.

+ Notch between the body and the tail.

f. Caudal papillæ.

g. Tail.

h. Imperfect loop or coil which the tail generally forms when not in use.

Fig. 232. A seminal animalcule less highly magnified, seen from the side. Great part of the tail is left out.

Fig. 233. Five seminal animalcules in apposition, packed like table spoons one within the hollow of the other.

Fig. 234. A seminal corpuscle and three isolated seminal globules.

Fig. 235 and 236. Entozoon from the folds of the conjunctiva of the eye of the horse (Filaria papillosa.)

Fig. 235. The entozoon of the natural size.

— 236. The same magnified 6 diameters.

a. Oral aperture.

b. Top of the œsophagus.

c. The intestine lying in coils.

d d. Part at which the animal was accidentally injured, and through which the intestine has protruded.

e. Anus.

f. The conical shaped point of the tail.

g g. The ovaries.

h h. The genital orifices.

Fig. 237. Ovum of an entozoon from the intestines of the horse, highly magnified.

Fig. 238. Acarus scabiei—magnified.

— 239. Development of the sebaceous glands of the skin from the palm of the human fœtus (Valentin.)

Supplement to the formation of the glands.

a. Round inversion of the epidermis.

b. The inversion advancing, a pediculated vesicle is formed.

c. The pediculated vesicle begins to turn round spirally like a corkscrew.

d. The follicle divides into two lappets. The excretory duct makes a complete spiral turn.

e. The two glands are completely divided, the elementary vesicles more numerous and more distinct. The excretory duct now makes three spiral turns.

f. The gland nearly perfectly evolved, consists of numerous elementary vesicles, which form botryoidal clusters, each vesicle connected by its duct with another, and all ending in one common efferent canal, which now makes four spiral turns between its origin and its termination on the surface.

Fig. 240. Several vesicular shaped pediculated epithelial cellular corpuscles from an intestinal villus (horse.) Addition to the lymphatics.

a. Epithelial corpuscles, which lie near the middle of the villus.

b. Epithelial corpuscles from the edge of the villus.

c. An epithelial vesicle seen from the side opposite to that to which the pedicle is attached.

d. Pediculated epithelial vesicles seen from the side.

Fig. 241. Peripheral vesicular reservoir (?) as the beginning of a lacteal vessel in the extremity of the villus, with the epithelial vesicles, the cellular investments of which have been omitted in the Drawing. This is an appearance that is frequently met with, but one the significance of which is still doubtful. In other villi these collecting vesicles rather compose peripheral retes.

a. Collecting vesicle, passing inferiorly into a rete of lymphatic vessels.

b. Absorbing epithelial vesicles?

Fig. 242. A magnified section of the epithelium and a portion of the mucous membrane of the root of the tongue of the horse prepared by boiling and maceration in oil of turpentine. Addition to the nerves.

a. The terminal festoons of the nerves upon the outer aspect of the integument, mucous membrane.

b. Scattered terminal loops penetrating the epithelium.

c. Several of them cut through slantingly.

d. Filamentous papillæ, upon the free surface of the tongue.

Figures illustrative of Mr. Gulliver's observations.

To avoid ambiguity it may be proper to mention, that I have employed the term *granules* to designate extremely minute particles, seldom above $\frac{1}{10000}$th of an inch in diameter, and the majority of them gradually diminishing in size until they become only just perceptible by the aid of the deepest magnifying powers. The larger granules are generally more or less globular, though often irregular in shape; but a great proportion of them are too minute to admit of their form being distinctly recognized even by the best instruments. It would be difficult, for instance, to determine the form of the particles composing the granular ground in Figs. 249 and 279. The phrase *granular matter* is applied to a shapeless assemblage of these granules, whether of the larger kind, of the larger and smaller mixed, or of the smallest of all. This granular matter frequently pervades a hyaline matrix; but it may be contained in cells, when of course it presents a more regular outline; indeed the very minute granules probably often coalesce, so as to form a great part of various corpuscles or globules. In the notes at pages 56 and 57, I find that the globules of the chyle and thymous fluid have been inadvertently spoken of as *granules* or *granular particles,* expressions which must not be understood in the sense as explained above, and in which these terms will be subsequently used. But as the chyle-globules and other analogous corpuscles have been termed granules by many anatomists, especially on the continent, I have, for the sake of perspicuity, named the peculiar base of the chyle the *molecular base,* as will be more fully explained in the Appendix.

G. G.

Fig. 243. Portion of opaque, white coloured, coagulated lymph, magnified about 380 diameters, from a case of

traumatic inflammation of the peritoneum of the horse. The lymph was very friable, and had only been a few days effused. It is composed of globules, smaller molecules, and granular matter in a hyaline matrix. In the lower part of the figure the granules and molecules are shown as floating in serous fluid from the clot. (See page 29; also fig. 272.)

Fig. 244. Portion of fibrine exhibiting an appearance of fibrils. Magnified nearly 700 diameters. From the heart of a child about 24 hours after death.

Fig. 245. Another portion of the same clot as in Fig. 244, similarly magnified, and showing a faint appearance of globules between the fibrils.

Fig. 246. Corpuscles in fibrine, obtained by whipping, from the blood of a horse. About the centre a corpuscle is shown, though obscurely, composed of a congeries of minute spherules, as mentioned in the note p. 34, and Appendix, p. 21. Magnified 700 diameters.

Fig. 247. Fibrine from the same blood as Fig. 246. The fibrine was boiled, and the corpuscles and fibrils are shown in a very thin slice. A cluster of the corpuscles is seen, though not very prominently, in the upper part of the figure. Magnified 700 diameters.

Fig. 248. The corpuscles rendered more distinct, and their nuclei shown, by the aid of acetic acid. The fibrine was obtained from the same blood as in Figs. 246 and 247. Magnified 700 diameters.

Fig. 249. Corpuscles in a clot of fibrine from the heart of a child, aged two months. The corpuscles have a corrugated appearance, and the intervening matter is very minutely granular. Magnified 800 diameters.

Fig. 250. Nuclei shown by soaking the fibrine for a while in sulphurous acid. The matrix has a finely granular appearance. From the fibrine of a horse, four days before death from inflammatory fever following an injury.

Fig. 251. Very distinct nuclei and faint envelopes, exposed by acetic acid, in fibrine from the venous blood of the horse. This and Fig. 250. were both made from bri ne in which it was difficult to distinguish the nuclei

or corpuscles till the acids were used. Both Figures were drawn with the camera lucida and a magnifying power of 800 diameters.

(The figures 243 to 251 are spoken of more fully in the note at p. 29, et seq. and in Sect. 5 of the observations on the blood-corpuscles of Mammiferous Animals in the Appendix.)

Figs. 252—255 exhibit the structure of *tubercle* made up chiefly of irregular corpuscles and cells, with oblong and circular nuclei. A very minutely granular matter is situated between the corpuscles and cells, which indeed it often seems to pervade. Fig. 252. is from a small crude tubercle of the lung, about as big as a hemp seed : the envelopes are very faint, and the nuclei of small size. Fig. 253. is from a similar tubercle which was situated immediately beneath the pulmonary pleura ; the envelopes are obscured by the granular matter, while the nuclei are of large size and distinctly marked. Fig. 254. is from a small tubercle obtained from the peritoneal coat of the small intestine ; the envelopes are here also very faintly seen, but the nuclei are perfectly distinct, and some of these inclose nucleoli. Fig. 255. shows very distinct cells, and nuclei containing spherical molecules in their substance, as appears also to be the case in some of the nuclei of fig. 254. In the lower part of fig. 255 an aggregation of similar molecules forms an oval corpuscle almost as large as a cell.

All the figures were made from portions magnified 800 diameters ; and in Figs. 252—254. the tubercular matter was of the common yellowish opaque kind, and obtained from a man, aged 26, who died of pulmonary phthisis; he had also numerous tubercles in the mesentery, in the omentum, and on the surface of the intestines. Fig. 255. was taken from a very minute tubercle from the surface of the ovary. The tubercular matter was paler than that which formed the subjects of Figs. 252—254, but still quite opaque. It was obtained from a woman, aged 48, who died of general dropsy connected with valvular disease of the heart. There was much fluid in the belly, and the peritoneum was throughout studded with tubercular accretions. The lungs contained only two or three small tubercles, none of which were in the active state.

Fig. 256. exhibits the structure of some whitish flaky matter from an enlarged ovarian cyst. Some distinct cells of large size are seen inclosing numerous minute spherules. Near to the top of the Figure these are aggregated into a corpuscle destitute of any envelope, close above which corpuscle is a cell nearly empty, and oval in shape. Many of the minute spherules seem to contain a still more minute nucleus. The cells are contained in a matrix, composed of oval nucleated corpuscles, of much smaller size, fainter, and quite distinct in character from the large circular cells. From the same woman as the tubercle shown in Fig. 255. Magnified 800 diameters.

Fig 257. Very singular baton-like bodies, mostly furnished with knobs at their extremities. There are also numerous minute spherules, and a flattened prismatic crystal; besides three large globular cysts, with extremely delicate parietes, but destitute, as far as could be observed, of nuclei or granules. The curious bodies first mentioned are perhaps crystals: Mr. Siddall showed me some similar bodies in the bile of a rabbit. The minute spherules exhibited remarkably vivid molecular motions. The drawing was made from some yellowish matter, not unlike thickened pus, or tubercle, obtained from a small tumor in the choroid plexus of a man who died of pulmonary phthisis. Magnified 800 diameters.

Fig. 258. Pus from a chronic abscess in a scrofulous child affected with hip disease and ulceration of the vertebræ. This pus is seen to be made up chiefly of minute spherules with granular matter, and the globules are fewer and less distinct than in healthy pus. They seem to be destitute of the two or three nuclei contained in healthy pus globules, though mostly containing minute spherules of a granular matter. This scrofulous pus is also peculiar, as being quite unaffected by several reagents which act instantly on common pus. Acetic acid neither affected the

minute spherules nor the globules of this scrofulous matter, and the action of caustic alkalies on the globules was very faint. As neither acetic nor sulphurous acid would act on the globules, of course no regular nuclei could be seen, and the pus was instantly coagulated by these acids, and therefore immiscible with them. Like healthy pus, this scrofulous matter was creamy and homogeneous, and readily miscible with water. A quantity of the pus dried and heated on paper produced no greasy stain; and a bottle full of the matter was kept for a month, the temperature being about 55°, at the end of which time there was no putrefaction, and the particles had not subsided in the least, so that there was no supernatant serum. Magnified 800 diameters. (See Notes, p. 92 and 95.)

Figs. 259—260. Globules of pus, showing the remarkable manner in which they swell out, on the addition of water. In both figures the globules are magnified 800 times in diameter. Fig. 259. exhibits them without water. Fig. 260. after the addition of water. Perfectly fresh pus shows the phenomenon best, for after the matter has been kept some time, the change either does not take place, or is comparatively slight. The Drawing was made from gonorrhœal matter immediately after it was taken from the urethra. In the upper part of the fig. the nuclei of two of the globules are very distinctly seen.

Fig. 261. *Pus-cells,* and their contents. On the right, near to the margin, is a congeries of pus molecules, or nucleoli, without any envelopes. A pus cell, *a*, is seen to enclose the pus globules *as nucleated nuclei.* Another cell, *b*, encloses an aggregation of molecules, or nucleoli. The pus cells are about $\frac{1}{1140}$th of an inch in diameter. Several corpuscles, one of which is marked *c*, have much the size and appearance of pus globules, but, on comparison with the cells, give the idea of the latter, with their contents, in progress of growth or evolution. Magnified 800 diameters.

Fig. 262. Abnormal pus. Only six or seven regular pus globules, one of which is marked *a*, are present. The rest

of the matter is made up of spherical bodies, giving the idea of oil globules. Some of these are very large, as at *b;* others, of extremely small size, are scattered about singly; some are aggregated into corpuscles merely by apposition, *c;* and others are connected together by a minutely granular matter, *d.* The molecules forming the corpuscle *c* had a slightly oval figure, though the artist has made them circular. Magnified 800 diameters.

This and the preceding Figure were taken from the pus of a large abscess in the buttock, connected with disease of the hip-joint from injury. The patient was a man, aged 31, who died of the affection. Fig. 261. shows the cells in the pus a month before death; Fig. 262. the abnormal pus just previous to death. In both specimens the pus was of good consistence, of the usual colour in the first mentioned, but brownish in the last. The latter pus did not grease paper when dried on it by heat.

Fig. 263. Corpuscles or *spongioles* of the liver magnified 800 diameters. The texture of these bodies seems to be very loose or spongy, and they contain a congeries of very minute spherules. From the horse.

Fig. 264. The same from a child.

Fig. 265. Corpuscles of the spleen magnified 800 diameters. As noticed in the Appendix, p. 23, I have seen these in the blood of the splenic vein. From a man.

Fig. 266. The oil-like spherules of the supra-renal gland. These constitute the bulk of the gland, and may sometimes be found in the blood of its vein, as mentioned in the Appendix, p. 23. They frequently exhibit molecular motions, especially when mixed with water. Magnified 380 diameters. From a woman aged 64.

Fig. 267. The same spherules magnified 800 diameters. There are, besides, five larger circular corpuscles, presenting the appearance of faint cells with nuclei. These cell-like bodies, it will be observed, are not larger than the human blood discs, and are possibly th se somewhat altered. From a young child.

Fig. 268. Granulated or mamillated and angular parti-

cles, and the minute spherules of the blood, magnified 800 diameters. Some of the angular particles are star-shaped. From a sucking kitten immediately after death. (See Appendix, pp. 10 and 23.)

Fig. 269. Pus-like globules in the blood of a horse. There are five of these globules, which differ remarkably from the blood discs. The blood was taken from the animal while he was suffering from inflammatory fever. (See Appendix, p. 20—21.) Magnified 800 diameters.

Fig. 270. Corpuscles and minute spherules in tubercle, magnified 800 diameters. The corpuscles exhibited no change when treated with acetic acid; they are very irregular in form, and in this respect differ from the cells and nuclei shown in figures 252--255. From a portion of the common kind of crude tubercle, obtained from the lung of a woman aged 33, who died of pulmonary phthisis.

Fig. 271. Fragment of tubercular matter, magnified 800 diameters. It was obtained from the kidney of a man aged 80, who died of pericarditis. This tubercular matter appears to be void of regular structure, being composed of shapeless fragments, and a granular matter formed of minute spherules very variable in size.

Fig. 272. A bit of false membrane, magnified 800 diameters. Numerous corpuscles are seen, more or less globular, and having the character of primary cells; the intervening texture is formed of most delicate fibrils. As is generally observable in effused clots of lymph, several minute opaque granules are scattered throughout the tissue. The Drawing was made from a flake of the common whitish kind of false membrane, formed on the serous surface of the lung in a man aged 51, who died of phthisis and pleuro-pneumonia. In this case the structure of the effused matter seems to be further advanced than in the coagulated lymph depicted in Fig. 243.

Fig. 273. Vesicular corpuscles in some crude tubercular matter obtained from the pancreas of the patas. (Cercopithecus ruber, Geoff.) The smaller tubercular deposits so common in the thoracic and abdominal viscera of the quad-

rumana are frequently composed chiefly of this vesicular structure, and it may sometimes be seen in the minute tubercular accretions of the human subject, especially in those of the omentum.

Figs. 274 to 287 illustrate the anatomy of the chyle and of the lymphatic and thymous juices. All the figures, except 275, are magnified about 800 diameters.

Fig. 274. Plan of the molecular base of the chyle. The scale represents micrometer divisions of $\frac{1}{4000}$th of an inch; and as from six to nine of the molecules are required to extend across one space, it may be inferred that their diameter is from $\frac{1}{36000}$th to $\frac{1}{24000}$th of an inch. It is obvious, however, that the result of any method of estimating the size of particles so extremely minute can merely be considered as an approximation to the truth; for it is perhaps questionable whether either the form or the magnitude of such objects can be satisfactorily determined. When examined, however, under the most favourable circumstances, the molecules have a spherical appearance; and quite as minute particles as these may be recognized in the most delicate granular matter, as in the ground of Fig. 279.

Fig. 275. Chyle from the peripheral lacteals in the mesentery of a kitten. There are six chyle globules, magnified fully 800 diameters, and the molecular base, which is magnified about 700 diameters, occupies the entire field.

Fig. 276. Chyle from a peripheral lacteal of a bitch. The molecular base as usual pervades the whole field, and five blood-smooth discs are contained in it. A few of the blood discs were observed in many trials, made with the greatest care to prevent the admission of blood to the chyle; but no chyle globules were present, although they were ascertained to be numerous in the chyle of a large central lacteal. The animal was fed plentifully, five hours before death, on boiled cow's paunch; and the lacteals were well distended with chyle.

Fig. 277. Chyle from a prick of a lacteal of a mesenteric gland of a puppy. The globules are very numerous, and

the effect of the molecular base is well depicted. It was obtained from the animal three hours after he had been fed with potatoes and boiled meat.

Fig. 278. Chyle from a prick of a turgid lacteal in a mesenteric gland of the same bitch as mentioned at Fig. 276. The chyle was very rich and white, and the molecular base accordingly appears richer than in Fig. 277, and the chyle globules are extremely numerous.

Fig. 279. Juice from the lymphatic gland of the ham of the same puppy as the chyle delineated in Fig. 277. The examination in both cases was made with the same glasses, and the two Figures give a faithful representation of the difference between the most minutely granular matter and the molecular base of the chyle. The globules in both figures appear to be identical, but in Fig. 279, the base in which they are contained is merely granular, and in Fig. 277 it is the characteristic molecular ground of the chyle.

Fig. 280. Lymphatic juice from an absorbent gland of the ham of a young bitch. In this instance, as is frequently the case, the fluid is pervaded merely by the globules, and a few much smaller spherical particles, which seem like nuclei of the former. But the action of acetic acid did not render the nucleated appearance clearer; and is here rather more distinctly represented than it was seen in the object under the microscope.

Fig. 281. Clot from the chyle of the thoracic duct of the same bitch as the lymphatic juice represented in the preceding Figure (280.) The clot contains numerous globules in a hyaline matrix, apparently pervaded by extremely delicate fibrils. The chyle was kept two hours in a glass tube, when the clot was removed with a needle and washed in water, so as to be in great part deprived of its opacity, before examination. As is generally the case, the globules of the clot appeared more irregular in size and shape than those of the fluid chyle; but this character is not well preserved in the Figure.

Fig. 282. Spherules of the whitish substratum resulting

from the mixture of æther with chyle: these appear more delicate and pellucid than oily spherules.

Fig. 283. Chyle globules treated with dilute muriatic acid. Most of them are somewhat enlarged, and exhibit an appearance of nuclei contained in transparent envelopes, probably from changes produced by the acid on the surface of the globules.

Fig. 284. Thymous fluid from the same puppy as the chyle Fig. 277, and the lymphatic juice Fig. 279. This thymous fluid is as usual rich in globules; and a few oil-like spherules are present. But it is totally destitute of the peculiar molecular base of the chyle, and a comparison with Fig. 277 will at once show the difference in question.

Fig. 285. Thymous fluid from a young ass.

Fig. 286. The same from a young dromedary. The globules are seen to be similar in shape to those of animals with circular blood discs. It will be recollected that the blood corpuscles of the dromedary are oval.

Fig. 287. Thymous globules of the same dromedary treated with acetic acid, by which they are rendered a little smaller, smoother on the surface, more distinct and translucent; the appearance of nuclei is more clearly seen than is usually the case after mixing acetic acid with thymous globules.

Figs. 288—291. Corpuscles in the muscular fibre of the heart, and in the mitral valve, magnified 800 diameters. The corpuscles may sometimes be seen, though rather indistinctly, without the aid of reagents. Acetic acid was used to render the corpuscles distinct for the drawings.

Mr. Bowman (Phil. Trans. part ii. 1840) has depicted similar corpuscles in the fibre of voluntary muscle, and Dr. Baly in the flat bands of some of the muscular fibres of organic life, (Translation of Müller's Physiology, part ii. plate 2. Fig. 9.;) but he does not mention the heart. The primary fascicles or bands of this organ are often so intimately connected, that it is difficult to see them distinctly; but they are sometimes tolerably well defined, often appearing flattened, occasionally nearly or quite cylindrical. I have given measurements of them, in some mammals, in the note at p. 237.

In mammals the corpuscles vary in diameter from $\frac{1}{6000}$th to $\frac{1}{2000}$th of an inch; in the newt they are considerably larger. They are very irregular in shape, being sometimes rounded, often either oval or spear-shaped, and frequently still more elongated.

They may be found in a great variety of tissues. Mr. Bowman has seen the corpuscles in the coats of the capillary blood-vessels, in the sheath of nerve, and in the substance of tendon, and I have repeatedly observed corpuscles, either much resembling those depicted in Fig. 288, or more elongated, in parts too numerous to particularize. I may mention, however, the bag-like portion of the pericardium, the peritoneum, semilunar valves of the arteries, the coats of veins, and of the seminal tubes, and the dura mater. By the aid of the aqueous solution of sulphurous acid and the acetic acid, the corpuscles may generally be brought into view: they are supposed to be the remains of the cells, from which the tissues were originally formed.

Fig. 288. Corpuscles in the tissue of the mitral valve: they are more numerous than in the muscular tissue of the heart.

Fig. 289. Corpuscles in the tissue of the auricle.

Fig. 290. Corpuscles in the tissue of the ventricle. This and Figs. 288 and 289 are from the hedgehog.

Fig. 291. Corpuscles, of much larger size than the preceding, in the fibre of the ventricle of a water newt. (Triton Bibronii, Bell.)

Fig. 292, Epithelial corpuscles, magnified 800 diameters, from the gullet of a newt, (Triton Bibronii, Bell,) to show their large size in this reptile. They are generally more or less oval, often round: the eliptical form also occurs frequently in nuclei of the cells of mammiferous animals. In the note at p. 42, I have noticed that the epithelial corpuscles of the frog do not exceed in size those of man. In another examination these corpuscles were found to be slightly larger than in man, but having no sort of relation to the great difference in size between the human and batrachian blood corpuscles. The lymph globules of the musk deer too are nearly or quite of the same size as those of man. In the water newt, however, the large size of the epithelial corpuscles, as well as of the colourless globules of the blood, is remarkable in connection with the magnitude of the blood discs of this reptile. From recent measurements I find the average length of its blood corpuscles to be $\frac{1}{848}$th, and the breadth $\frac{1}{1311}$th of an inch, linear. The diameter of the white globules of the newt's blood varies from $\frac{1}{3000}$th to $\frac{1}{1300}$th, and that of the epithelial corpuscles from $\frac{1}{2900}$th to $\frac{1}{888}$th of an inch.

Fig. 293. The same epithelial corpuscles after having been treated with acetic acid. They are only rendered rather smaller, and more distinct at their edges.

Fig. 294. Blood discs of a very young water newt, (Triton Bibronii, Bell) apparently in progress of formation from the colourless globules. A perfect blood corpuscle is shown (*a*) with its usual oval nucleus; all the other corpuscles represented in the figure were nearly or quite colourless, and their round nuclei are exactly like the colourless globules of the blood. In some the envelopes are forming evenly around the nuclei (*b*, *b*.) In others the corpuscles, though smaller than the regular discs, are oval in consequence of the envelope extending principally in opposite directions (*c*, *c*.) In none of these has the nucleus assumed its eliptical figure; but in one (*d*) this change would seem to be commencing. Occasionally the envelope was seen to begin in a crescentic form, arising from a part only of the circumference of the globule ; but of this no delineation is given.

In the blood of the newt, oval cysts full of granular matter are sometimes present (*e*.) They are generally as large, frequently larger, than the blood corpuscles.

As formerly mentioned (Appendix p. 24,) my observations on the formation of the corpuscles in the blood of birds were entirely negative. But in young reptiles of the genera Triton and Lissotriton, the blood corpuscles may be seen in the various states above described. Since the drawing was executed, I find that similar results have been obtained by Wagner (Physiology by Willis, part ii.) and Nasse (Unters. zur Physiol. 11, s. 138.) The latter describes the capsule as growing by offsets from opposite sides of the globule, while the former has always seen the envelope formed evenly around the globule. My own observations tend to reconcile this slight discrepancy, by showing that the evolution of the vesicle may take place in the manner described by both these eminent physiologists.

G. G.

END OF EXPLANATION OF PLATES.

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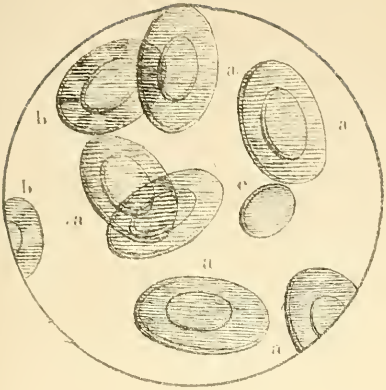

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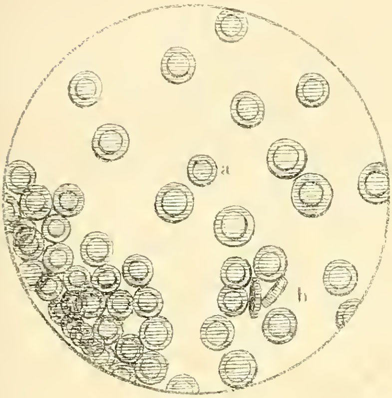

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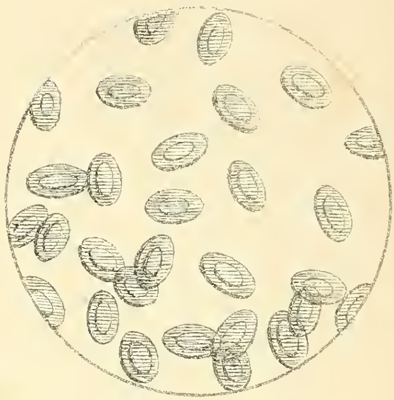

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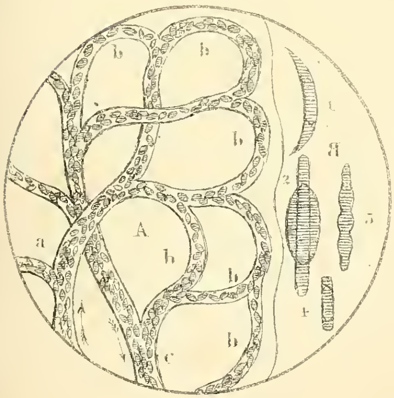

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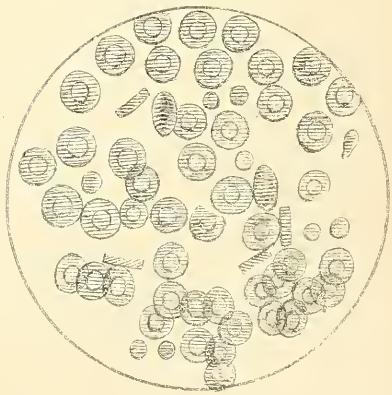

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GERBER'S GENERAL ANATOMY.

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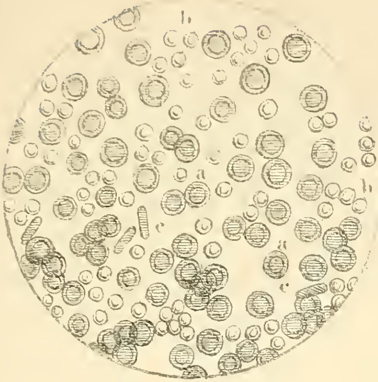

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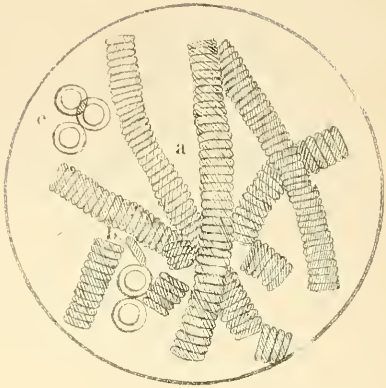

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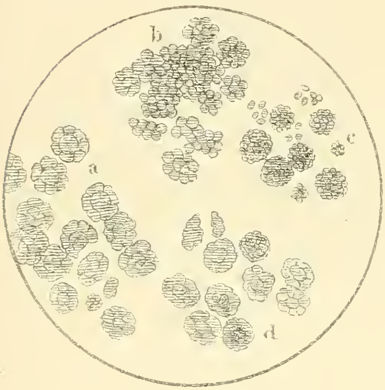

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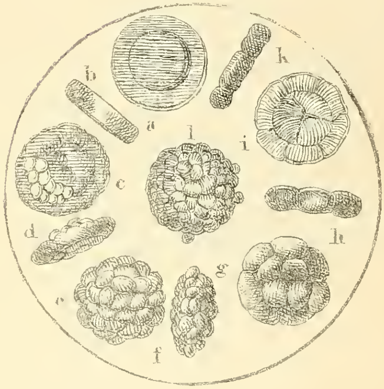

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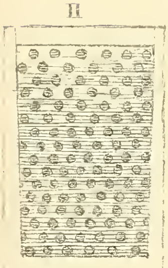

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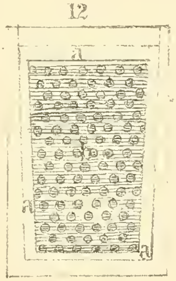

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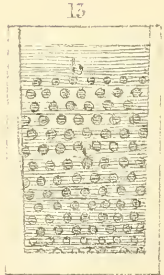

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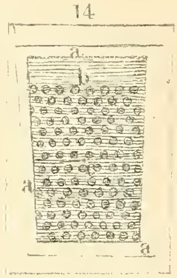

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F. 15

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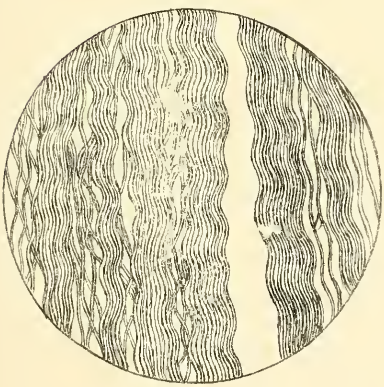

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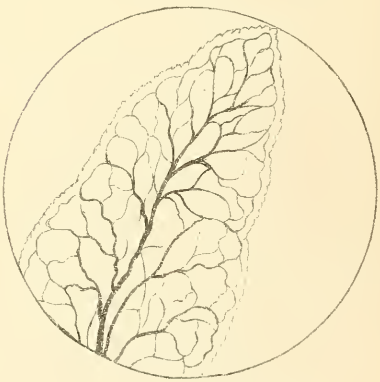

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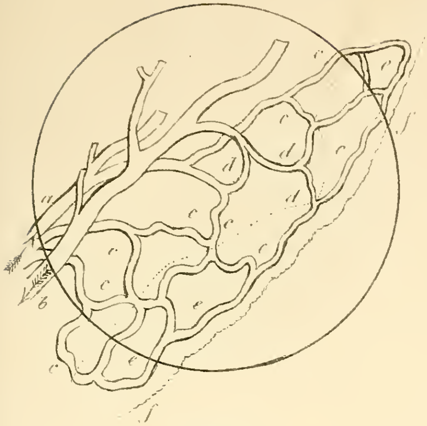

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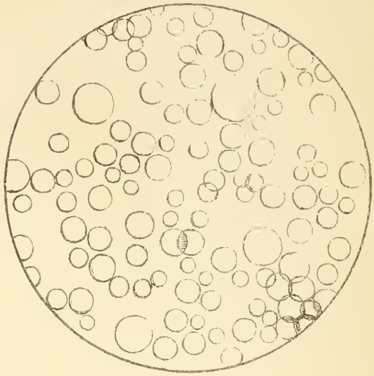

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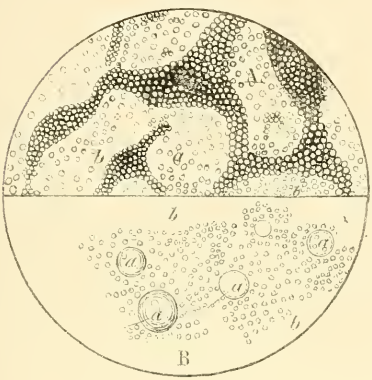

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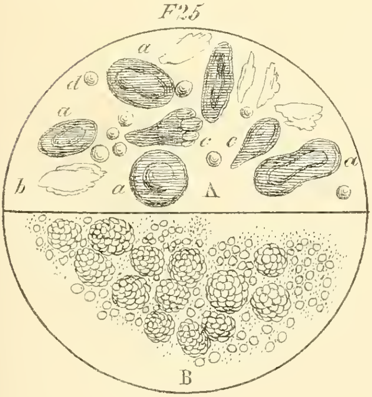

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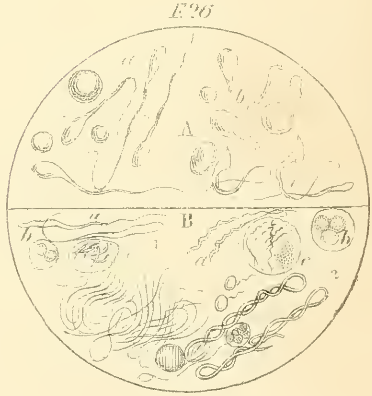

Lens Aldous del. on Zinc

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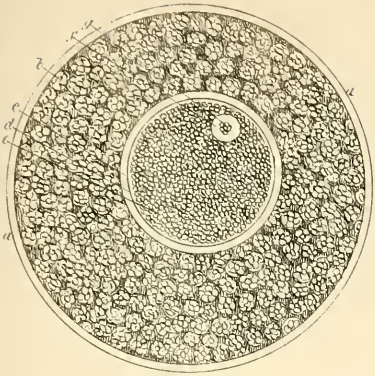

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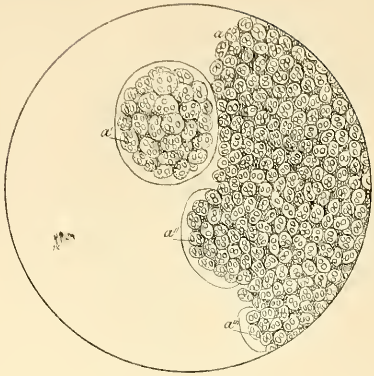

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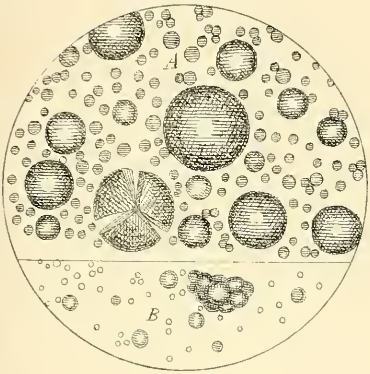

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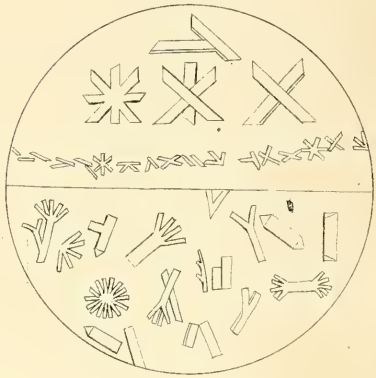

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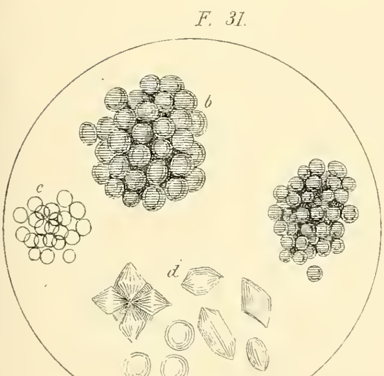

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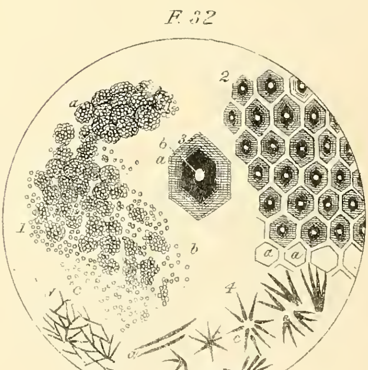

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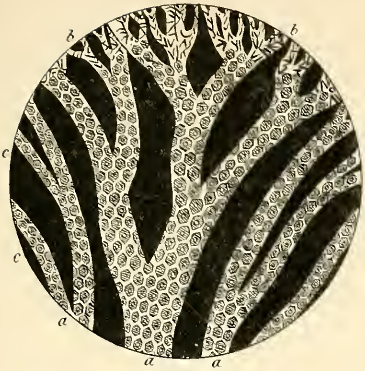

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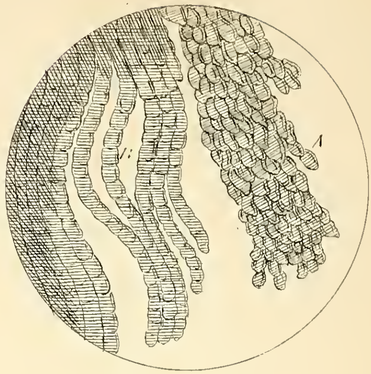

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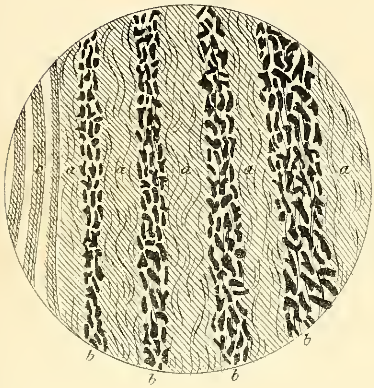

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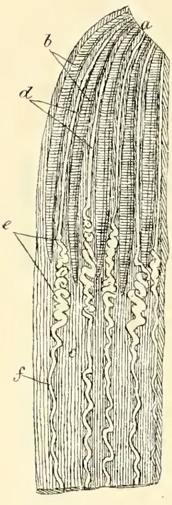

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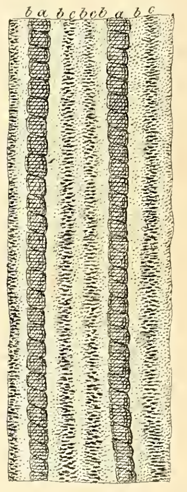

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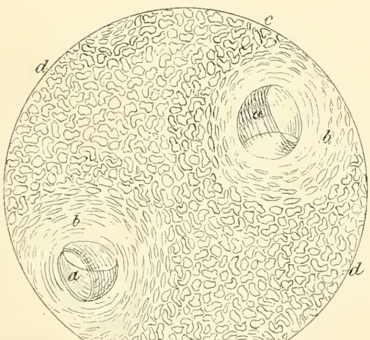

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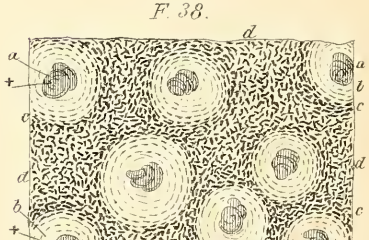

Mulley, Zinco.

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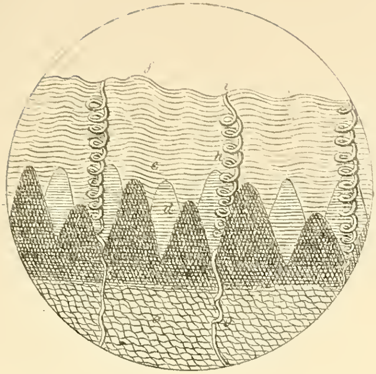

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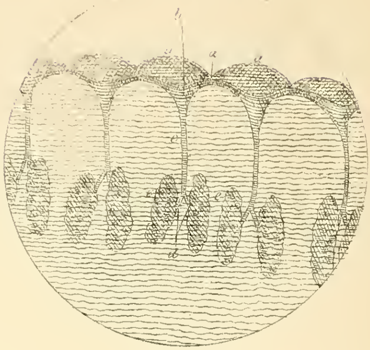

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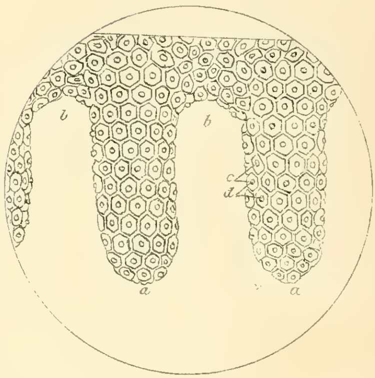

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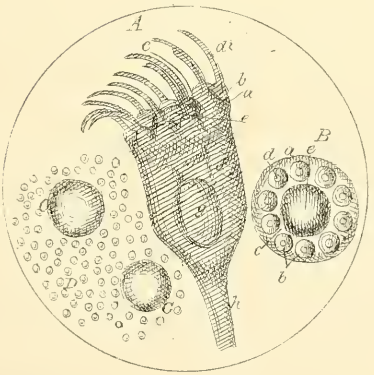

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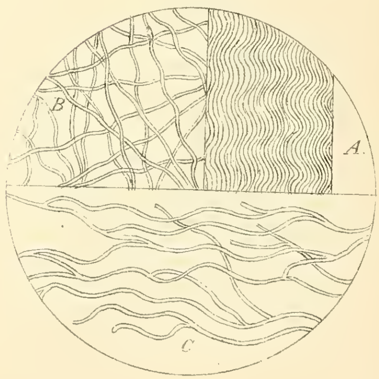

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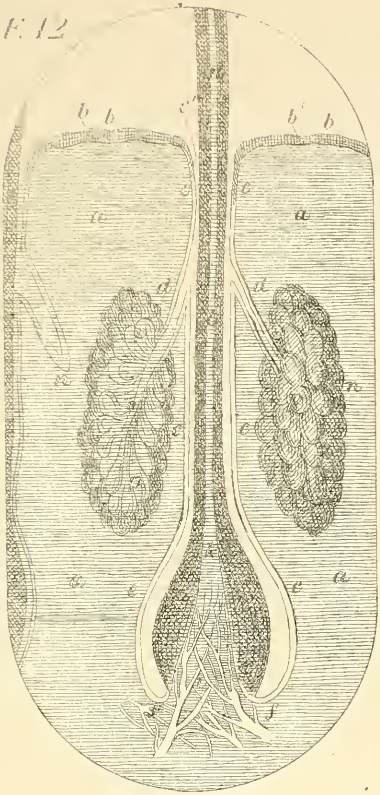

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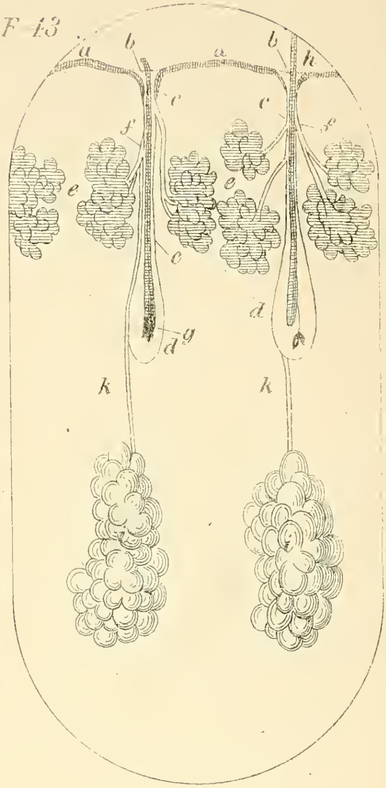

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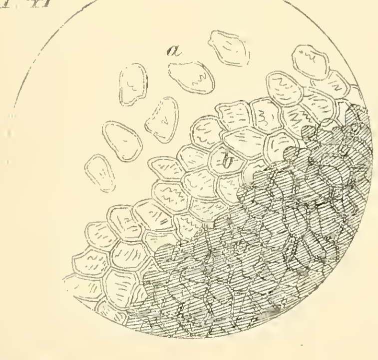

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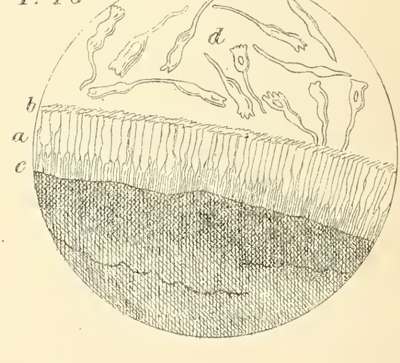

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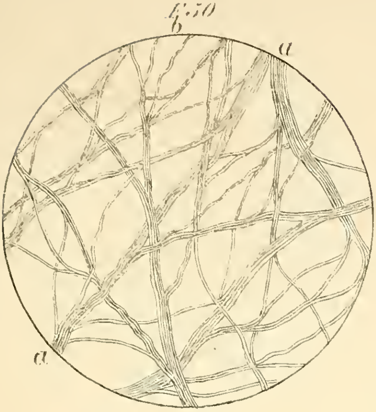

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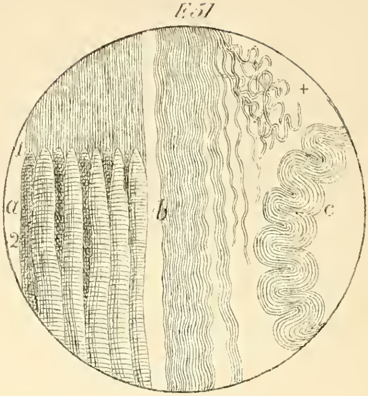

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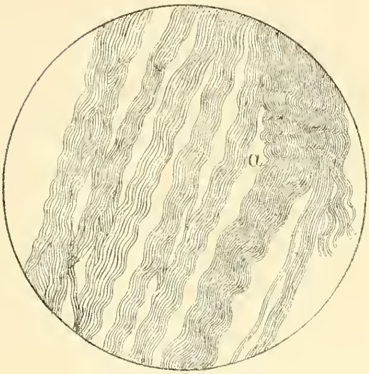

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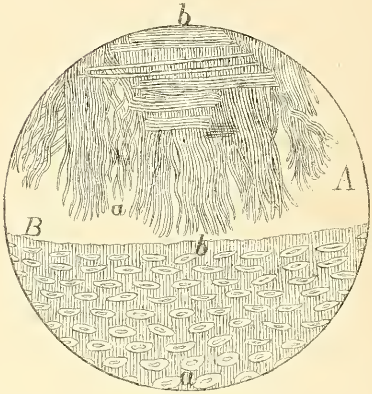

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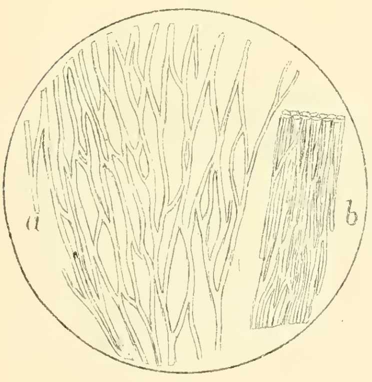

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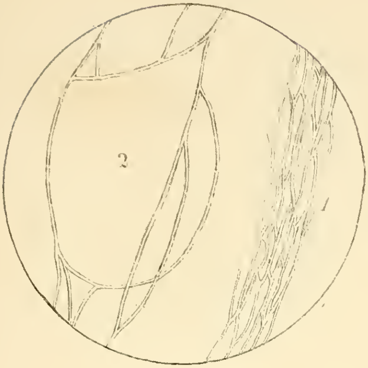

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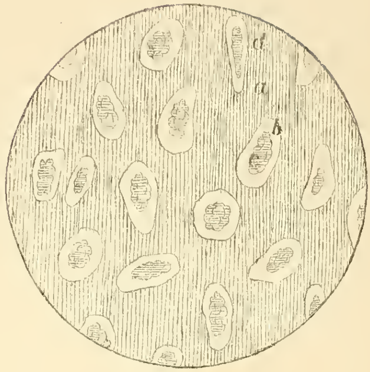

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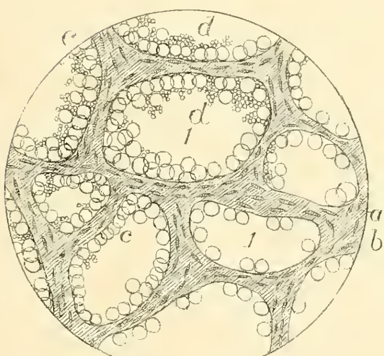

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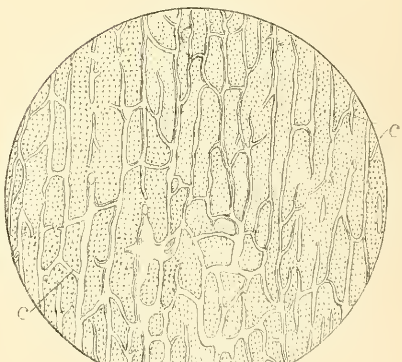

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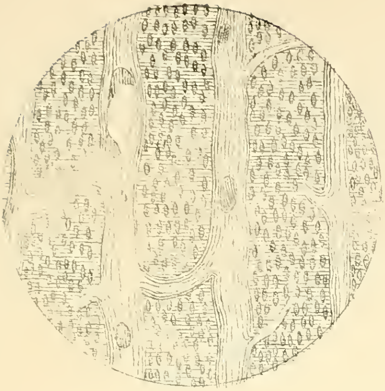

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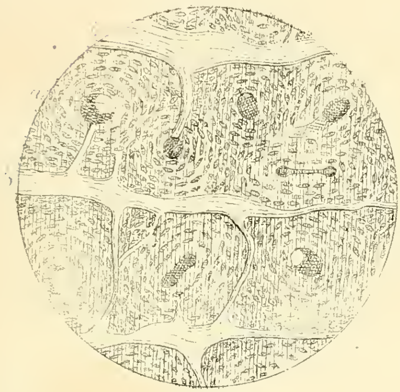

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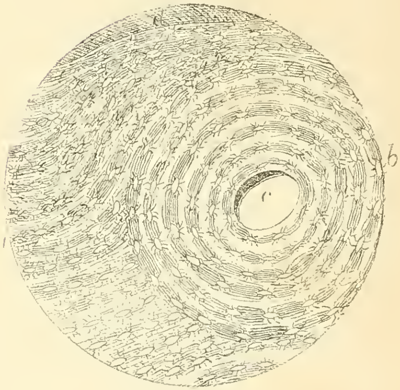

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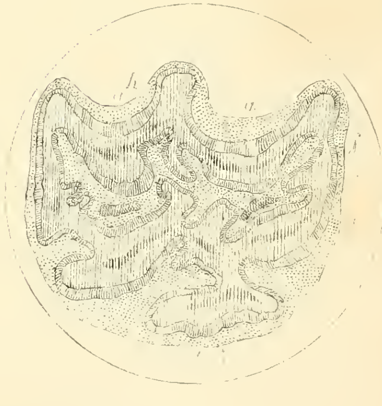

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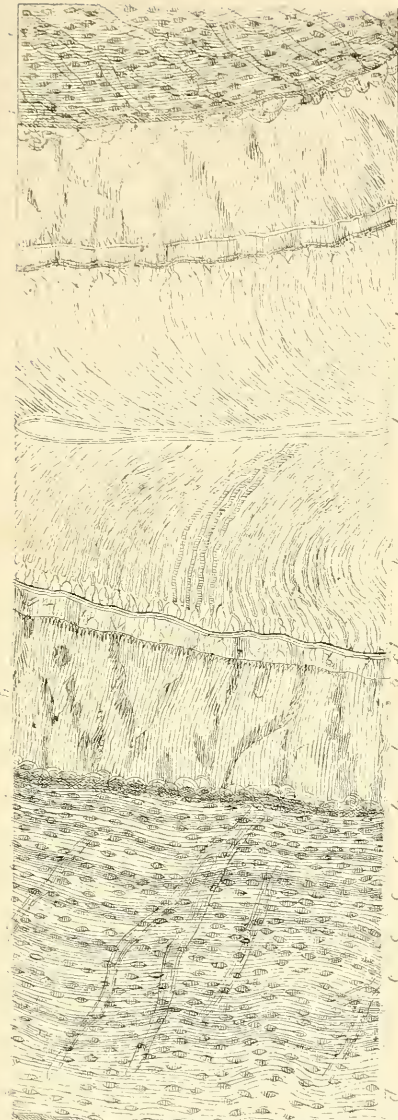

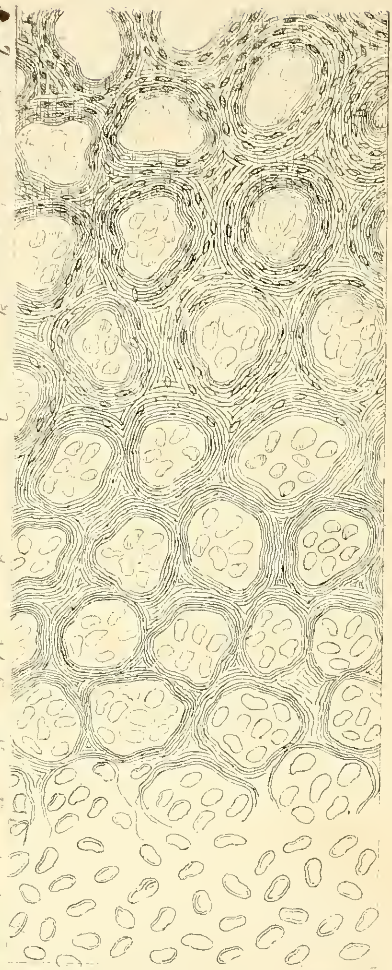

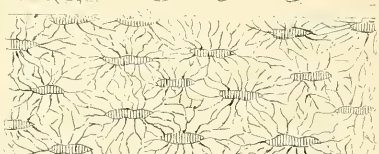

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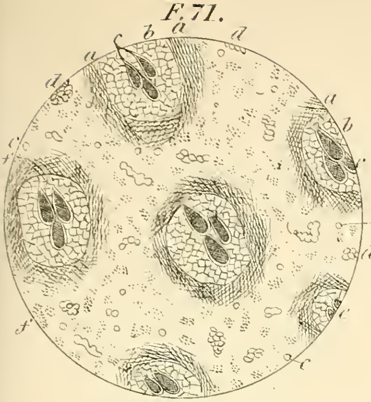

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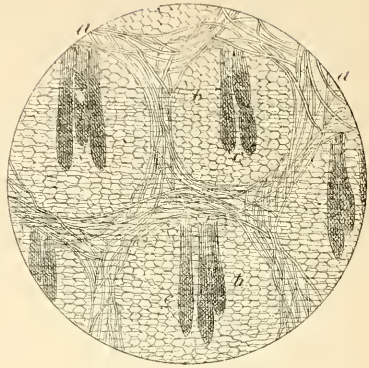

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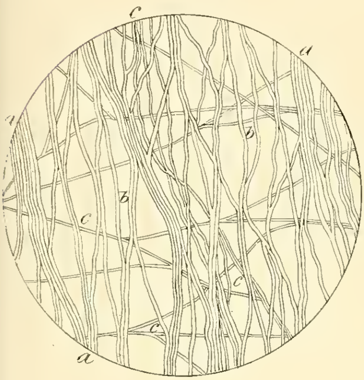

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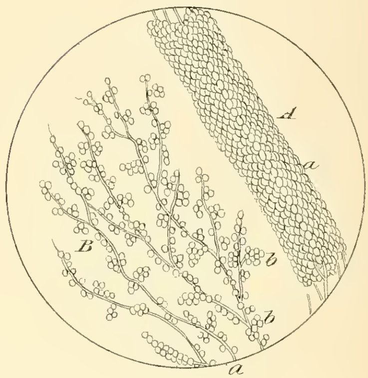

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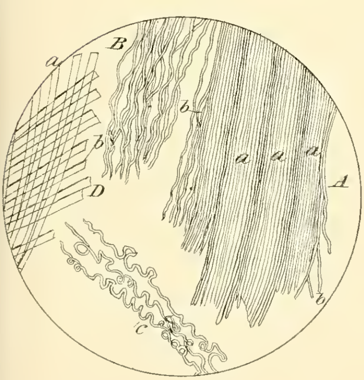

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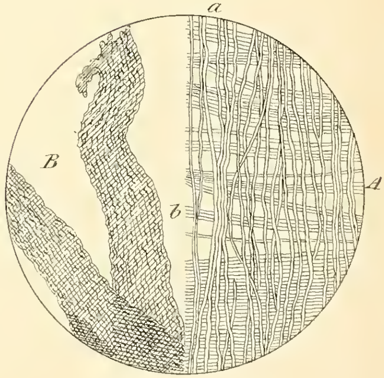

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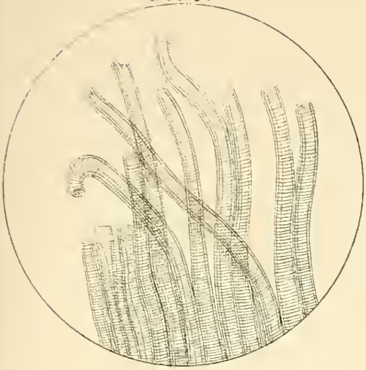

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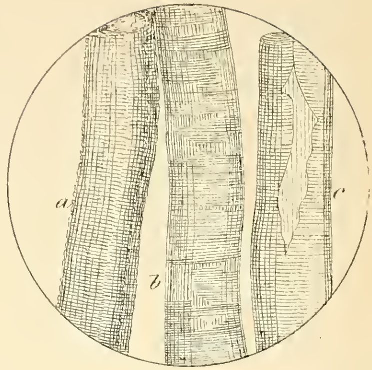

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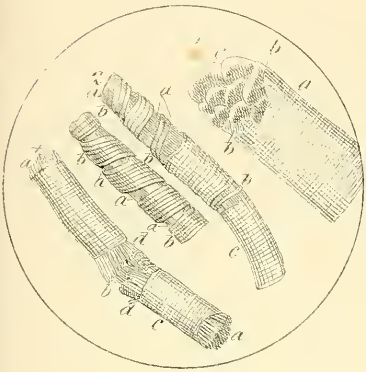

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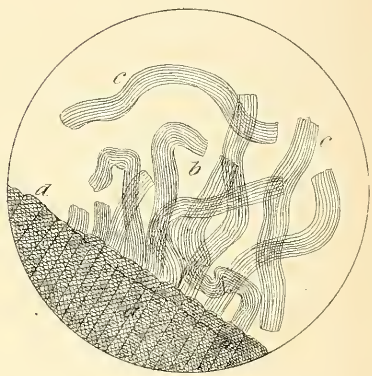

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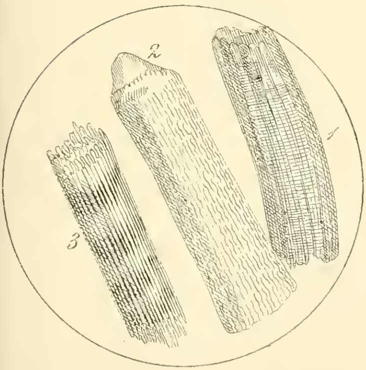

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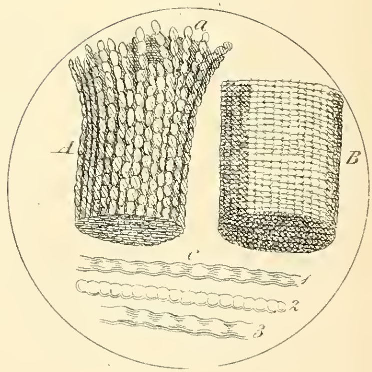

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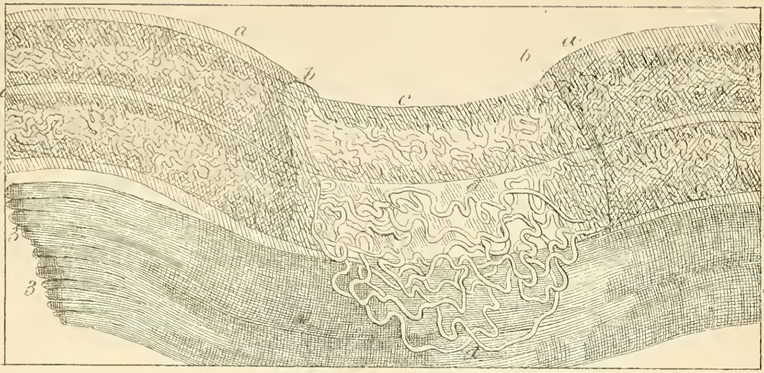

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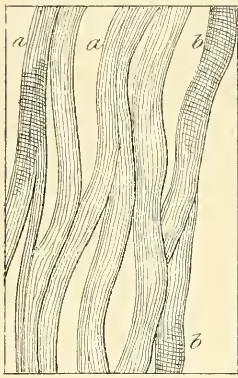

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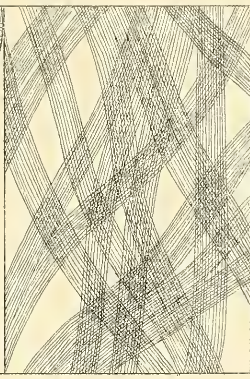

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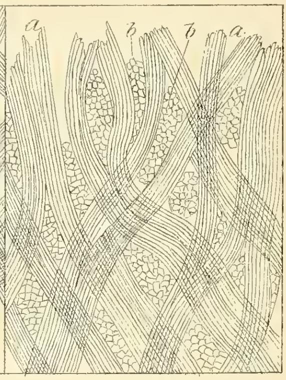

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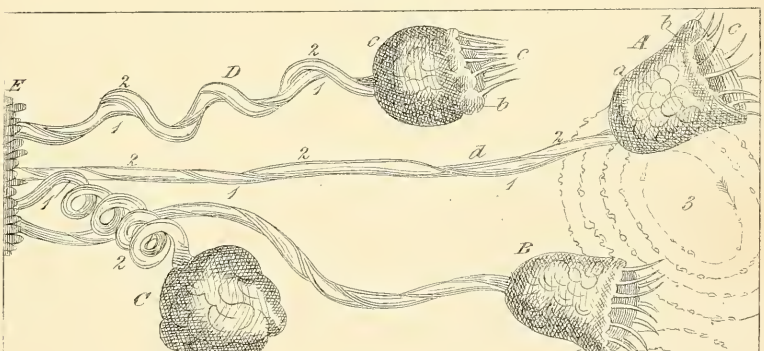

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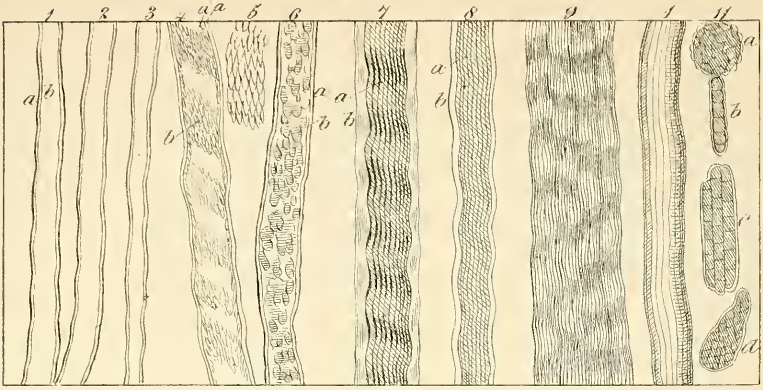

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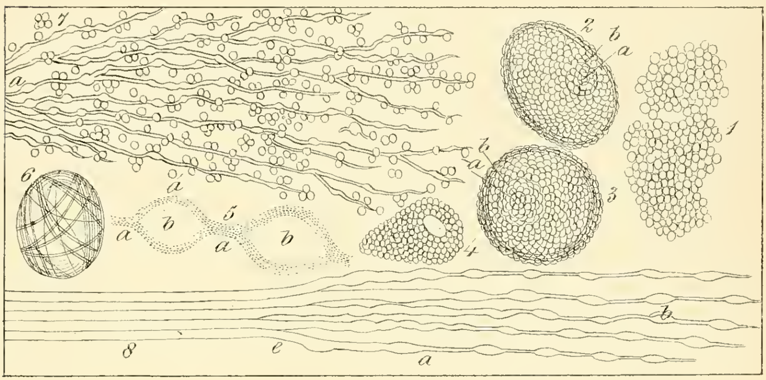

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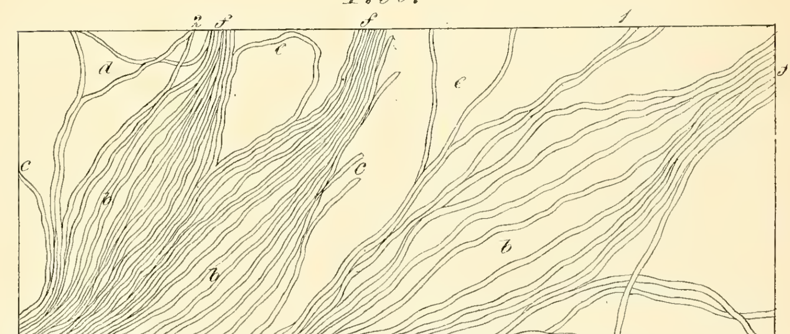

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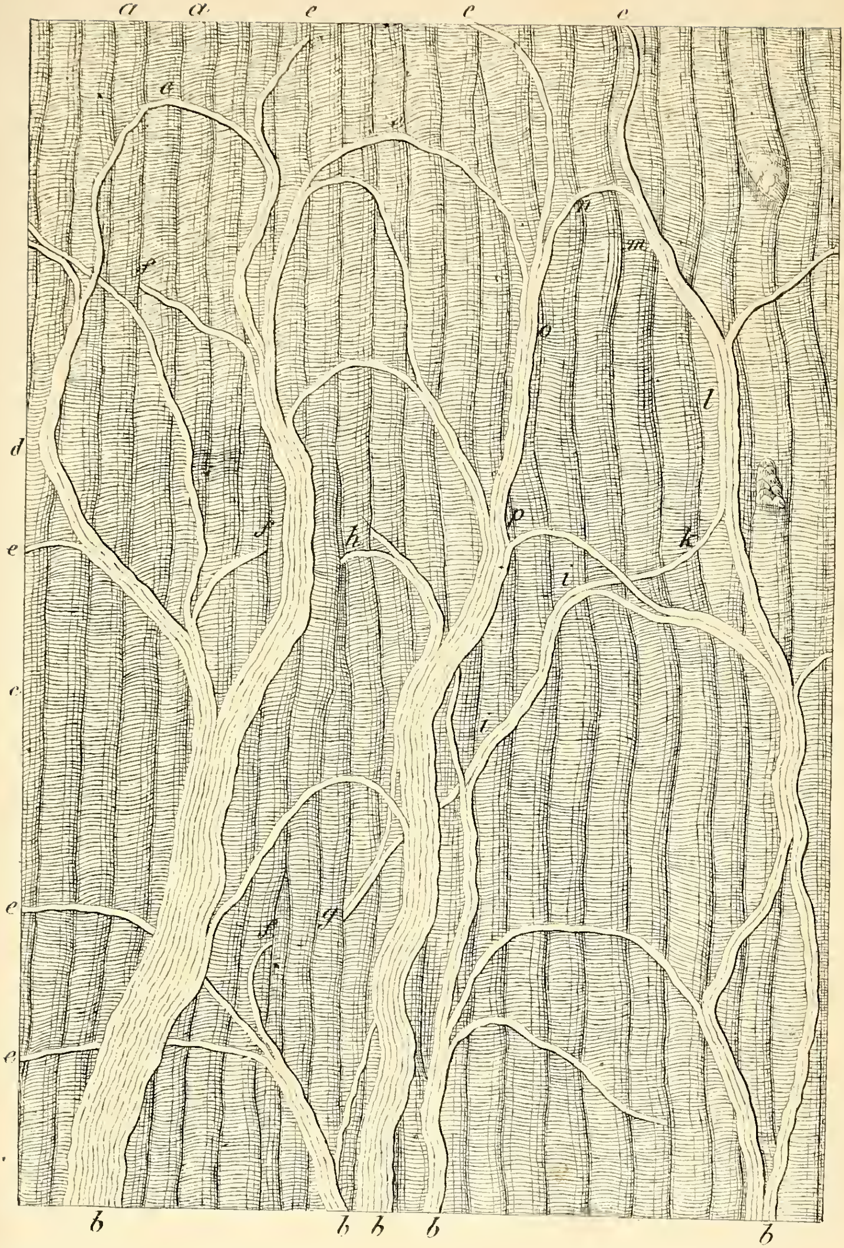

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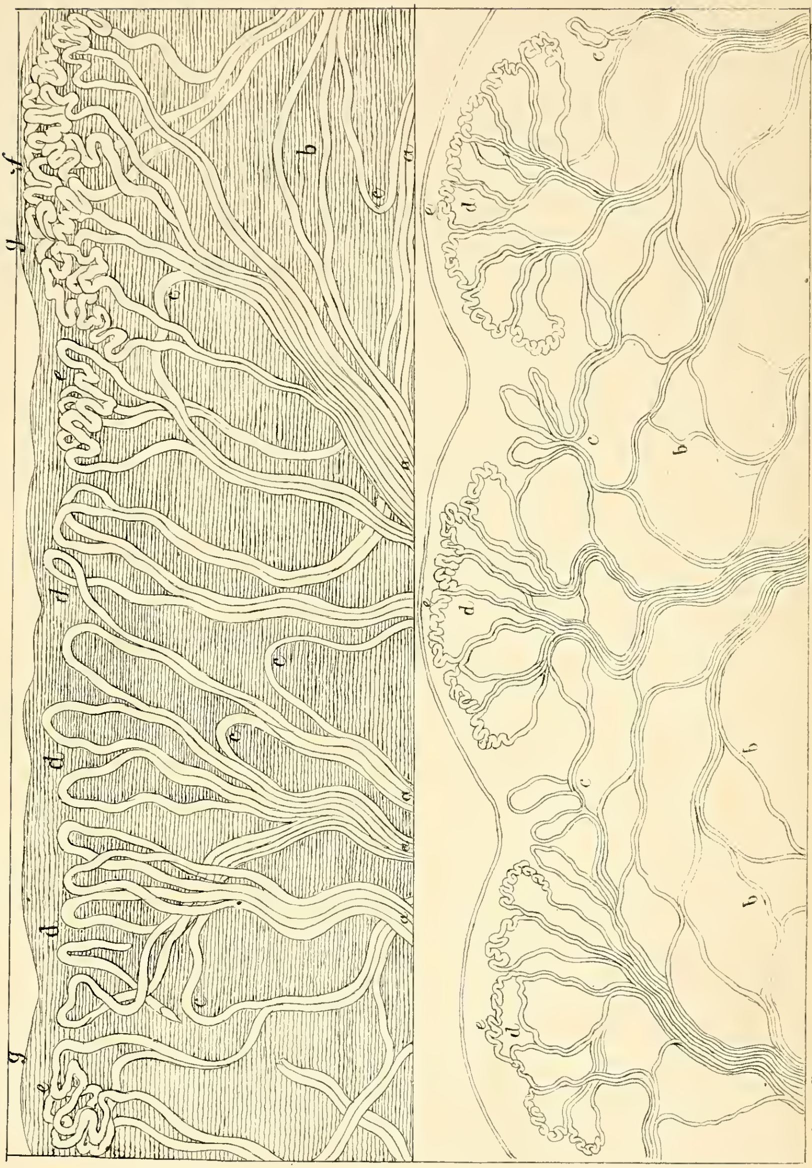
F. 92. F. 95.



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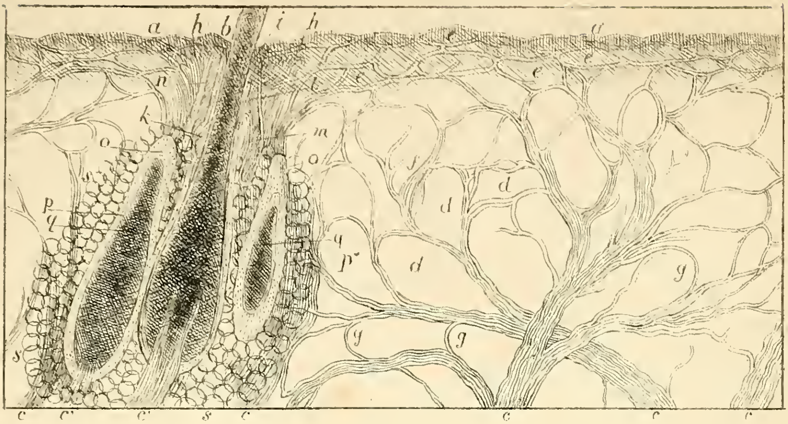

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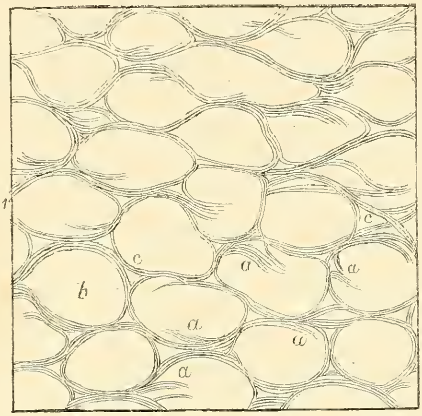

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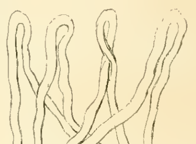

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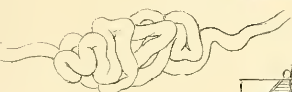

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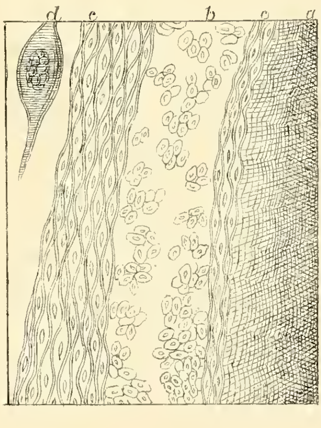

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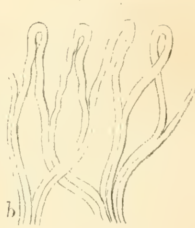

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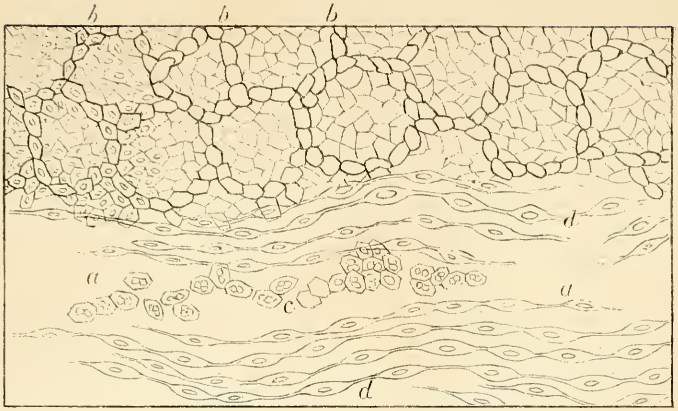

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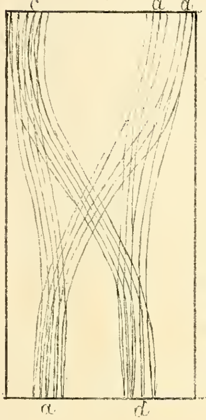

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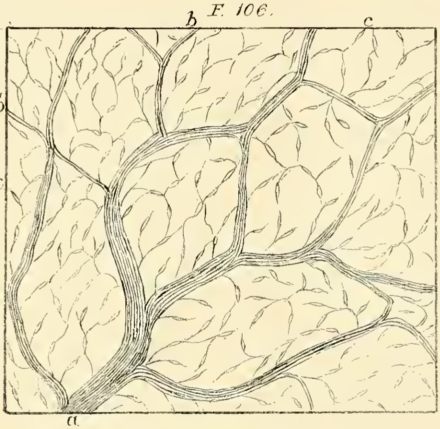

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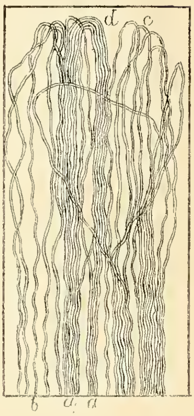

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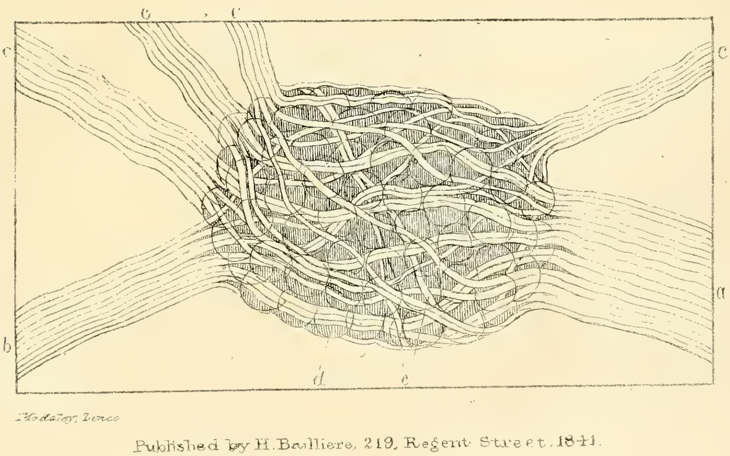

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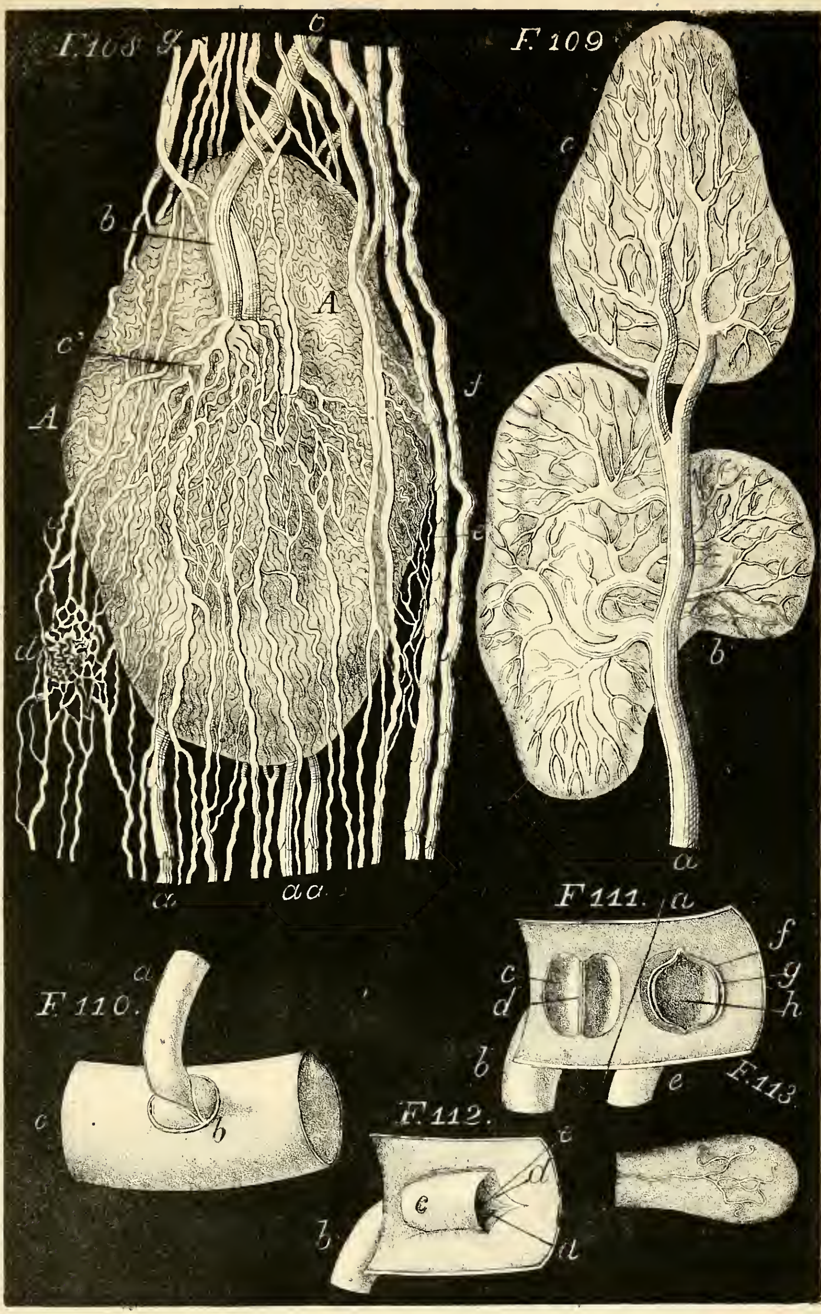

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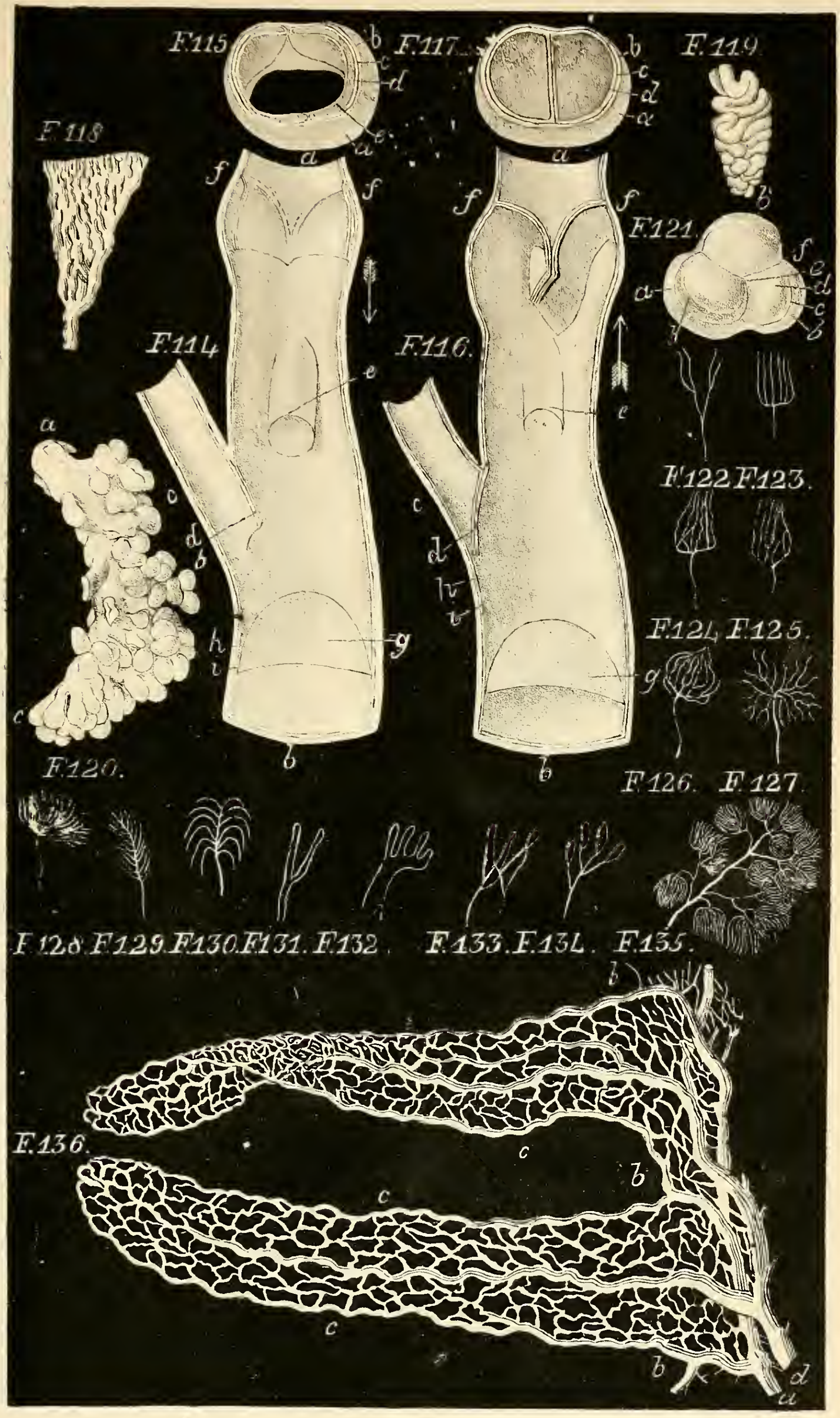

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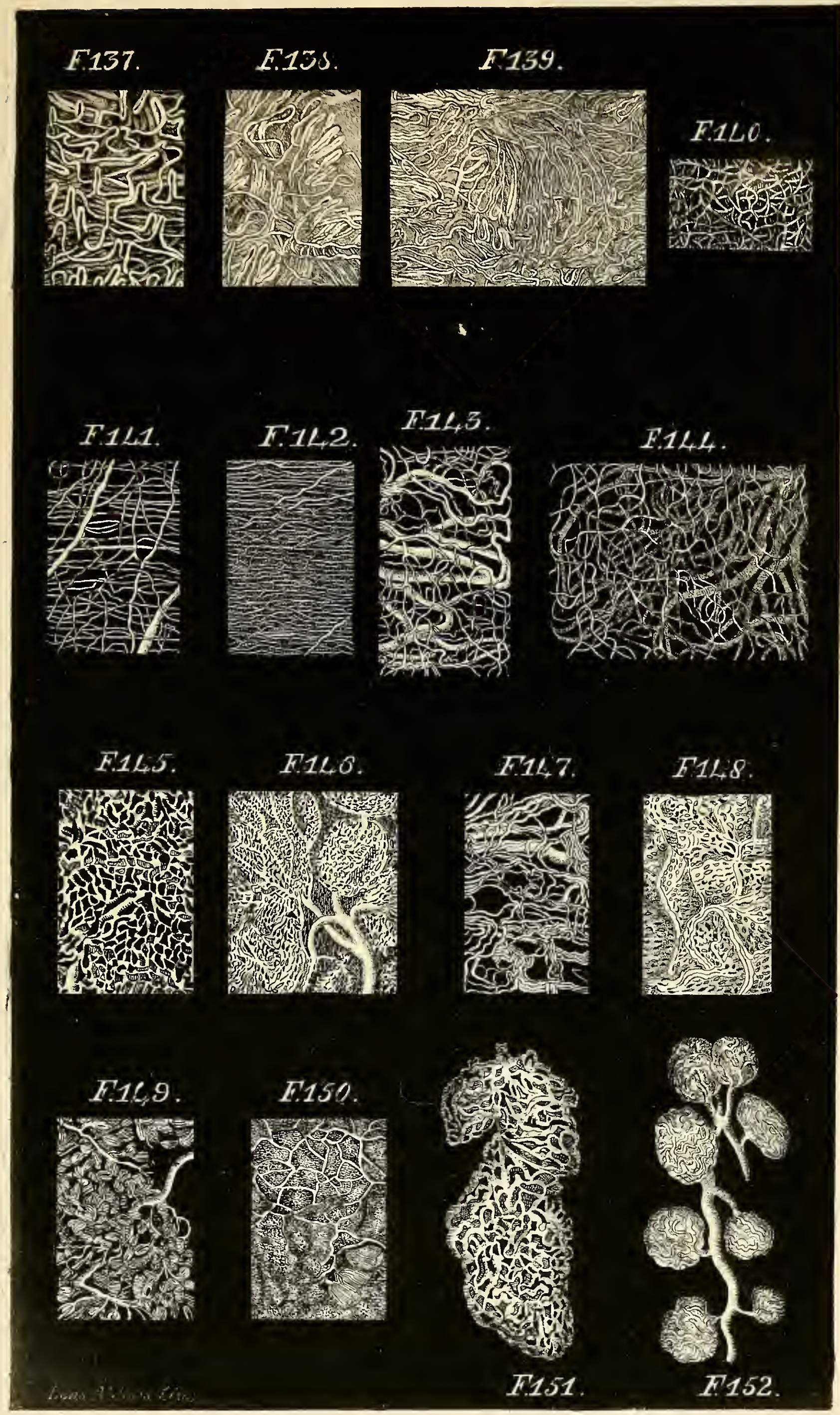

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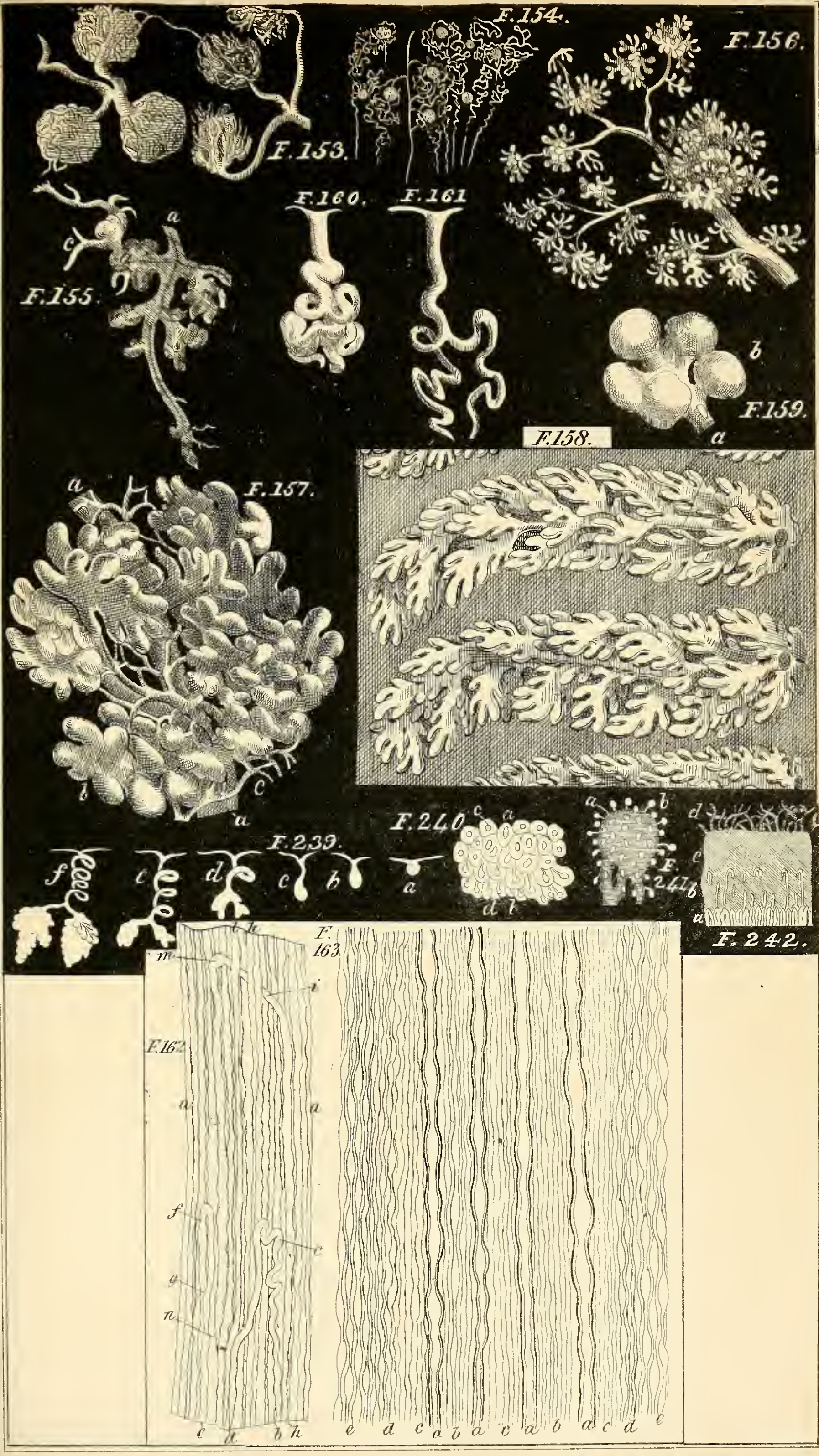
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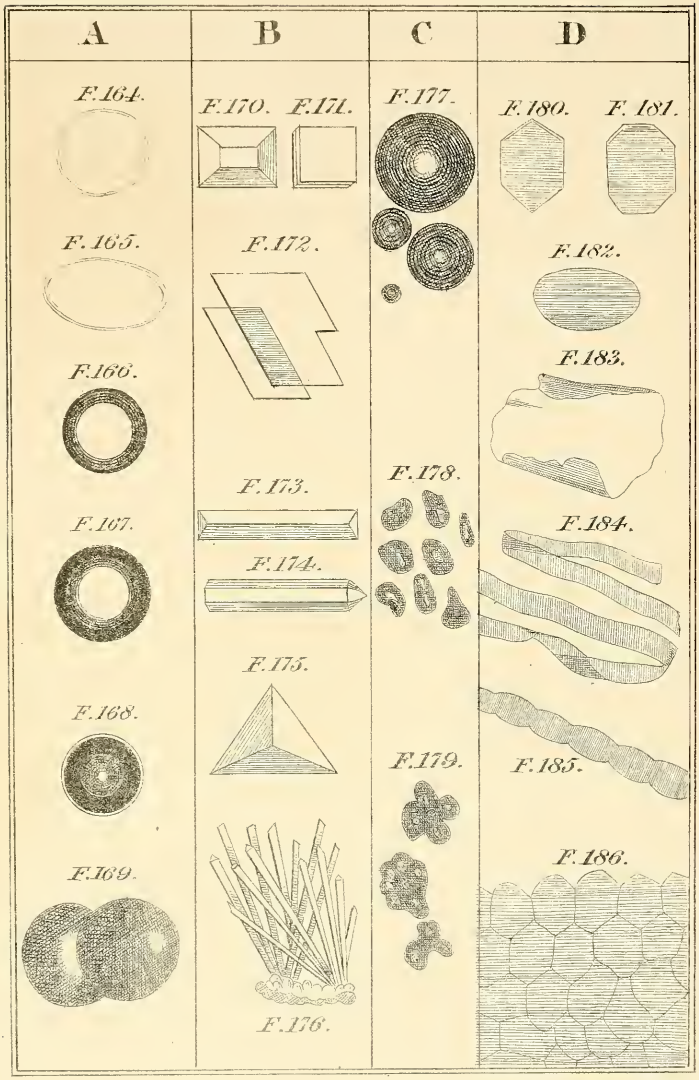
Pl. XXV.



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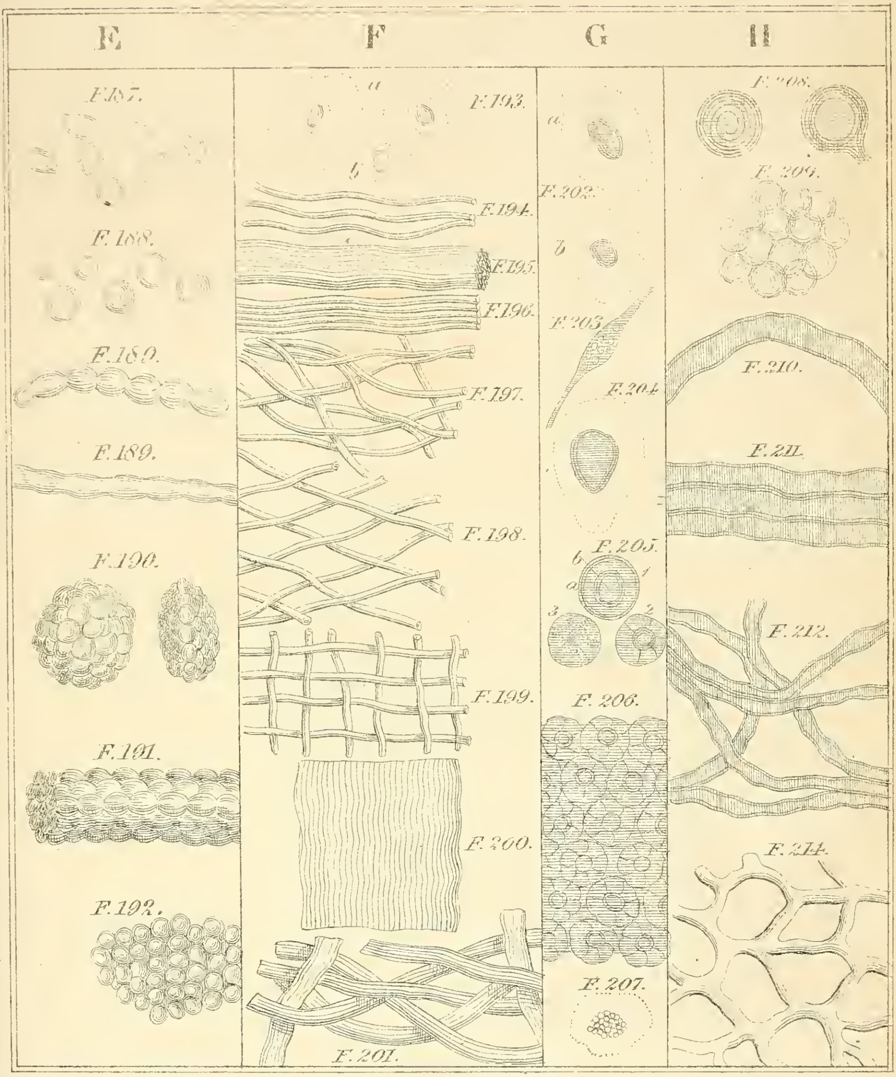

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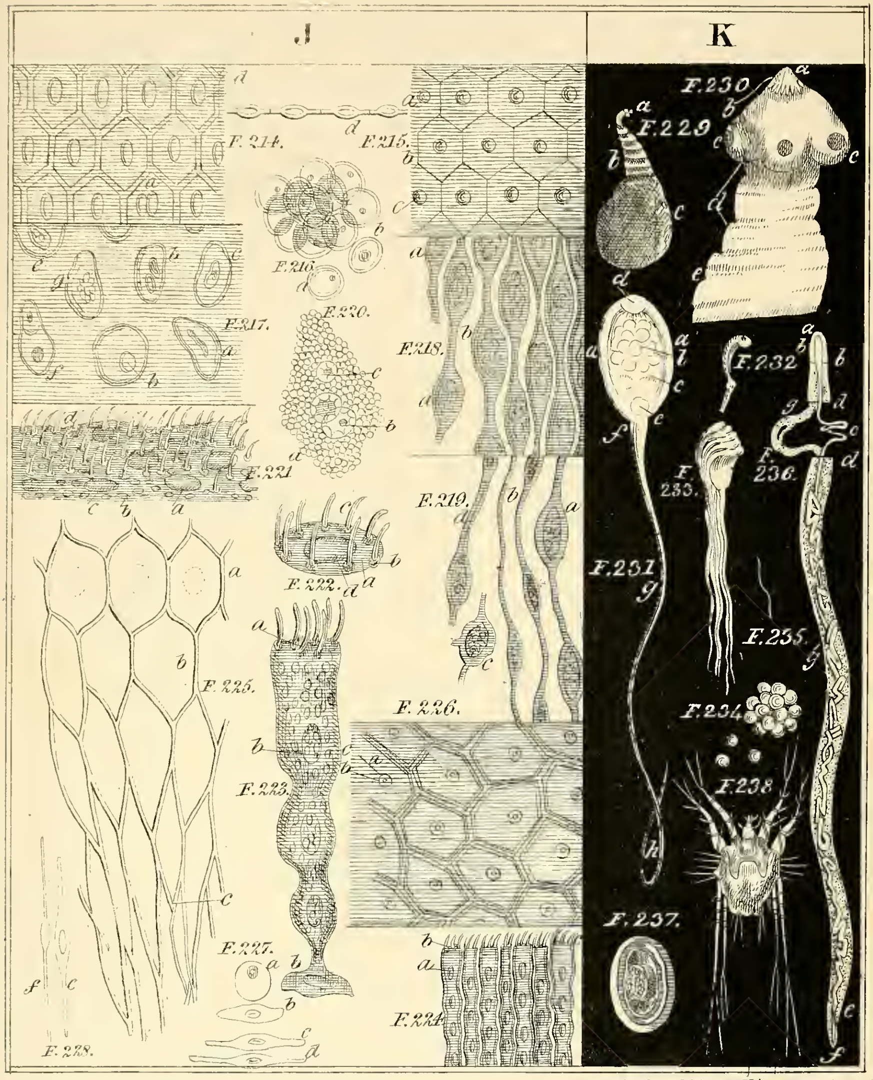

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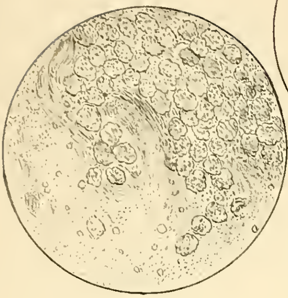

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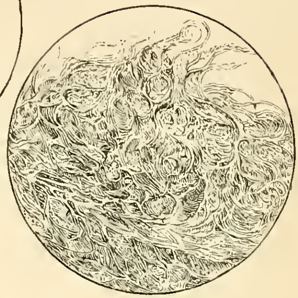

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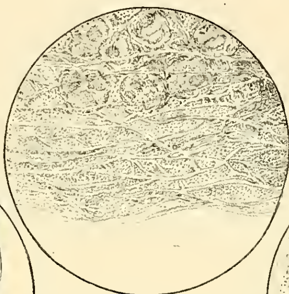

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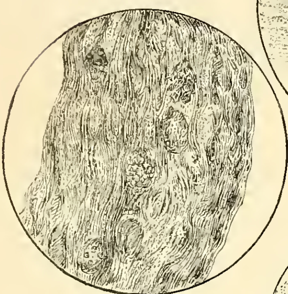

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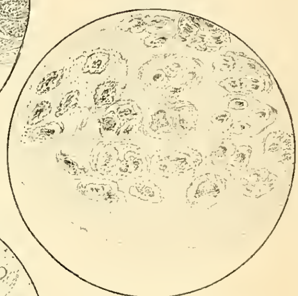

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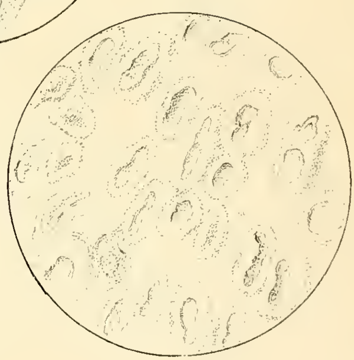

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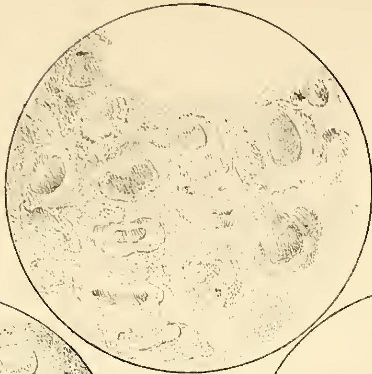

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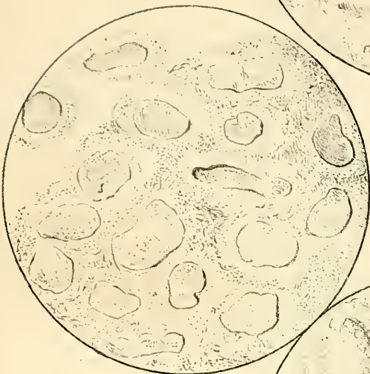

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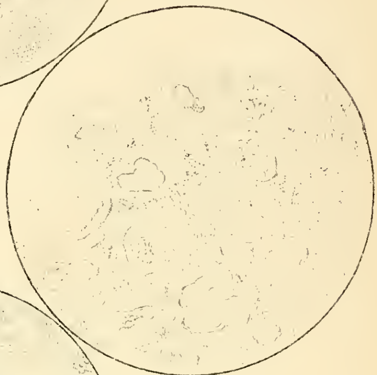

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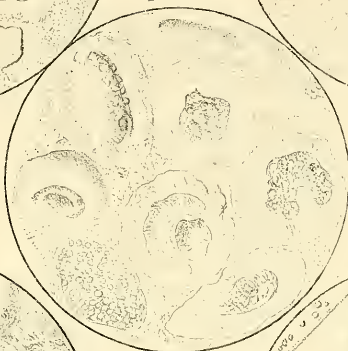

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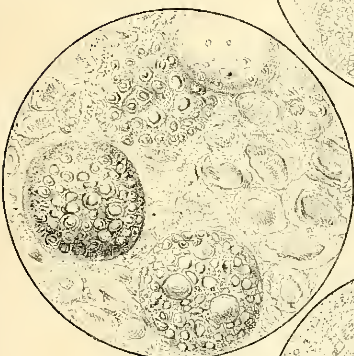

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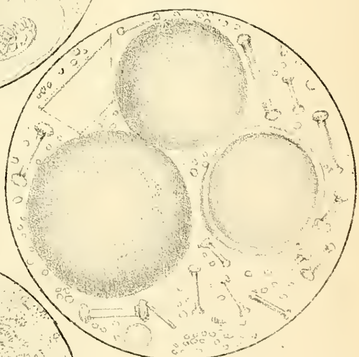

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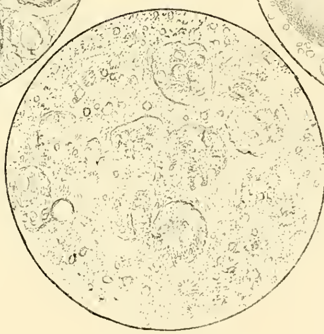

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Mr. GULLIVER'S FIGURES

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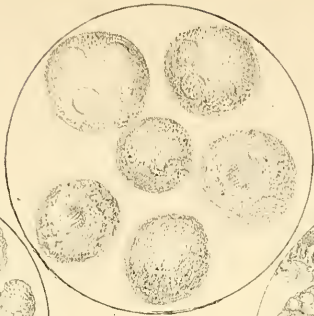

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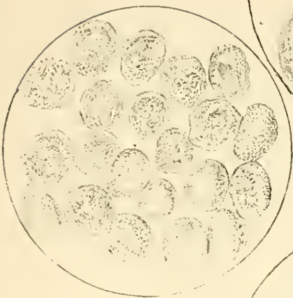

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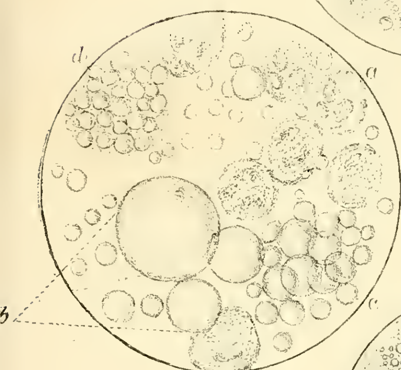

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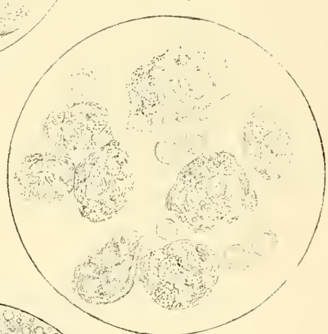

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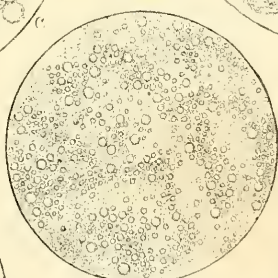

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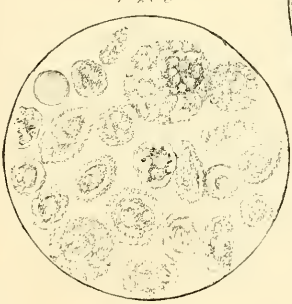

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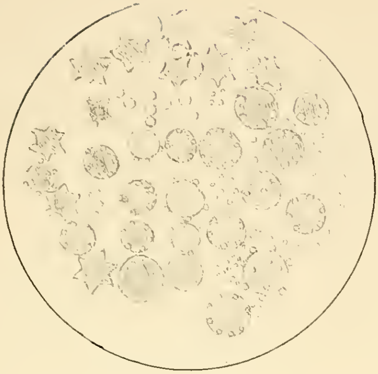

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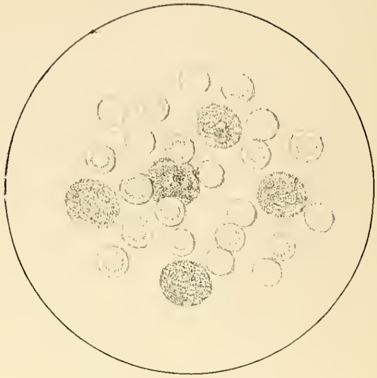

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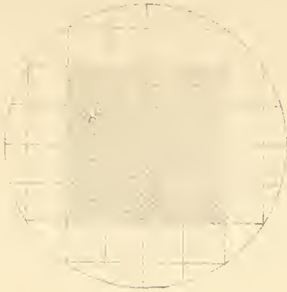

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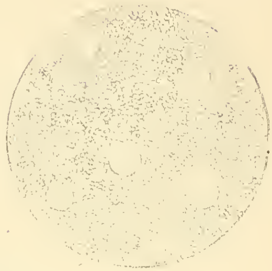

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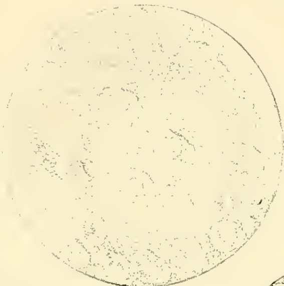

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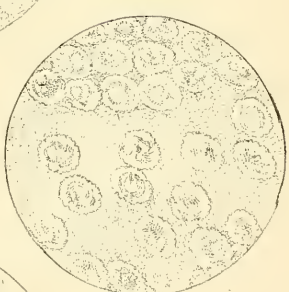

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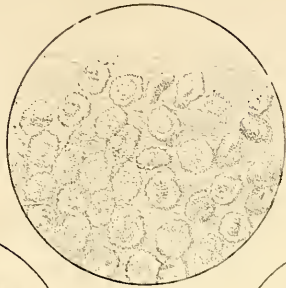
M^r. GULLIVER'S FIGURES. Pl. XXXIII.

F. 281.



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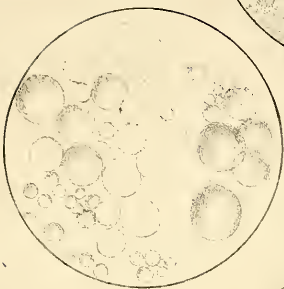

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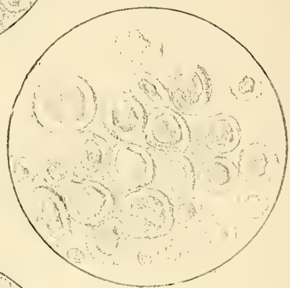

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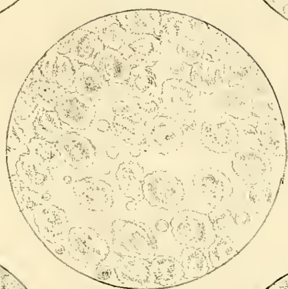

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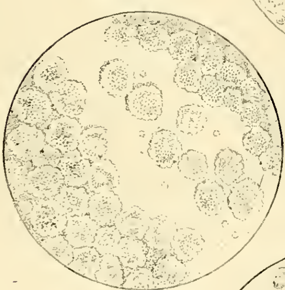

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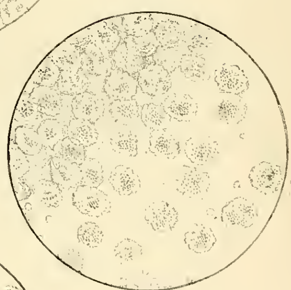

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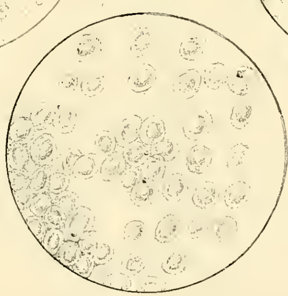

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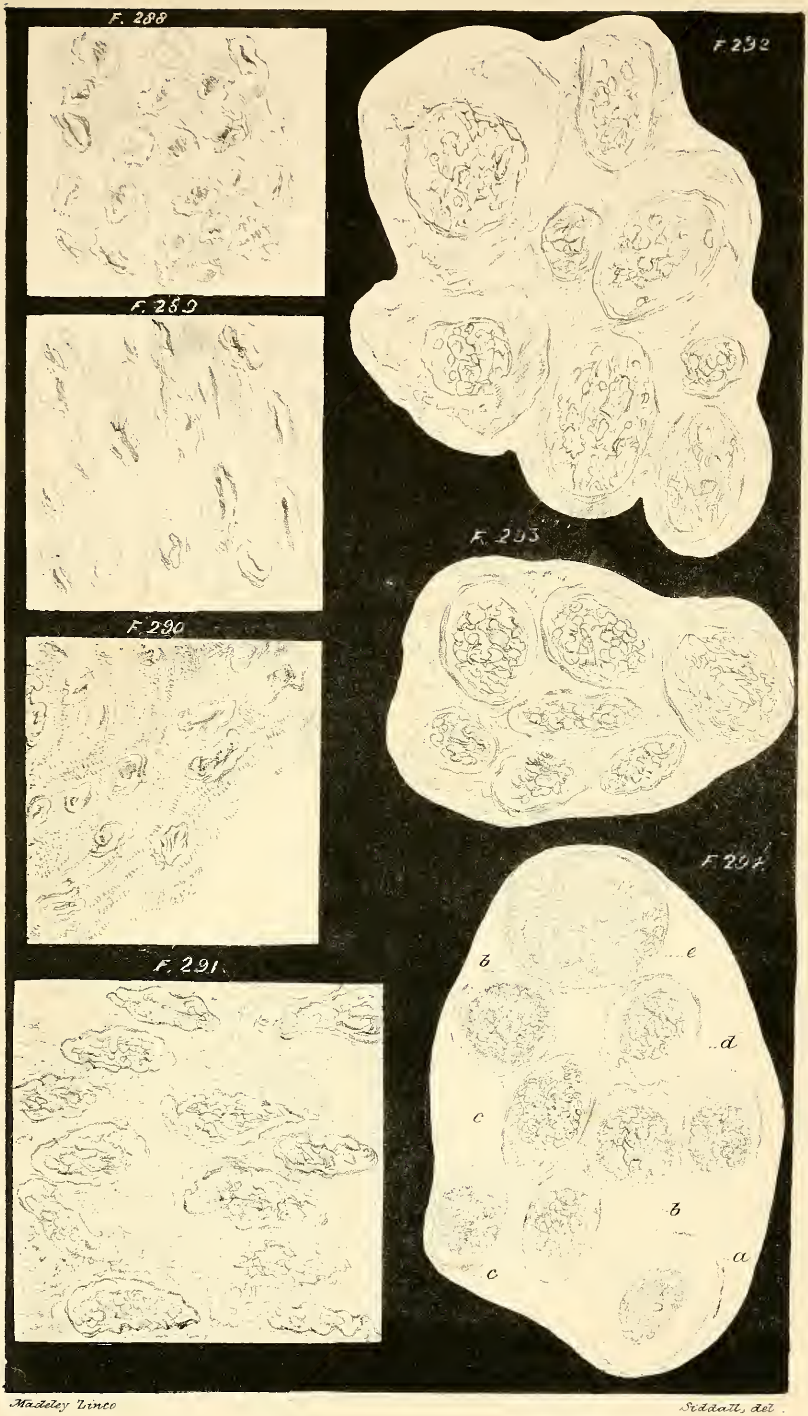

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Dear Sir

The undersigned were appointed by their fellow students to present to you the accompanying book, as a token of their esteem for the ability & zeal with which you have imparted to them a knowledge of that beautiful science, Auscultation, and for the deep interest you have manifested in their studies upon this subject. They beg of you to accept it, wishing you all possible prosperity & happiness.

Respectfully

D. D. Slade

Luther Parks jr.

March 8th 1847.